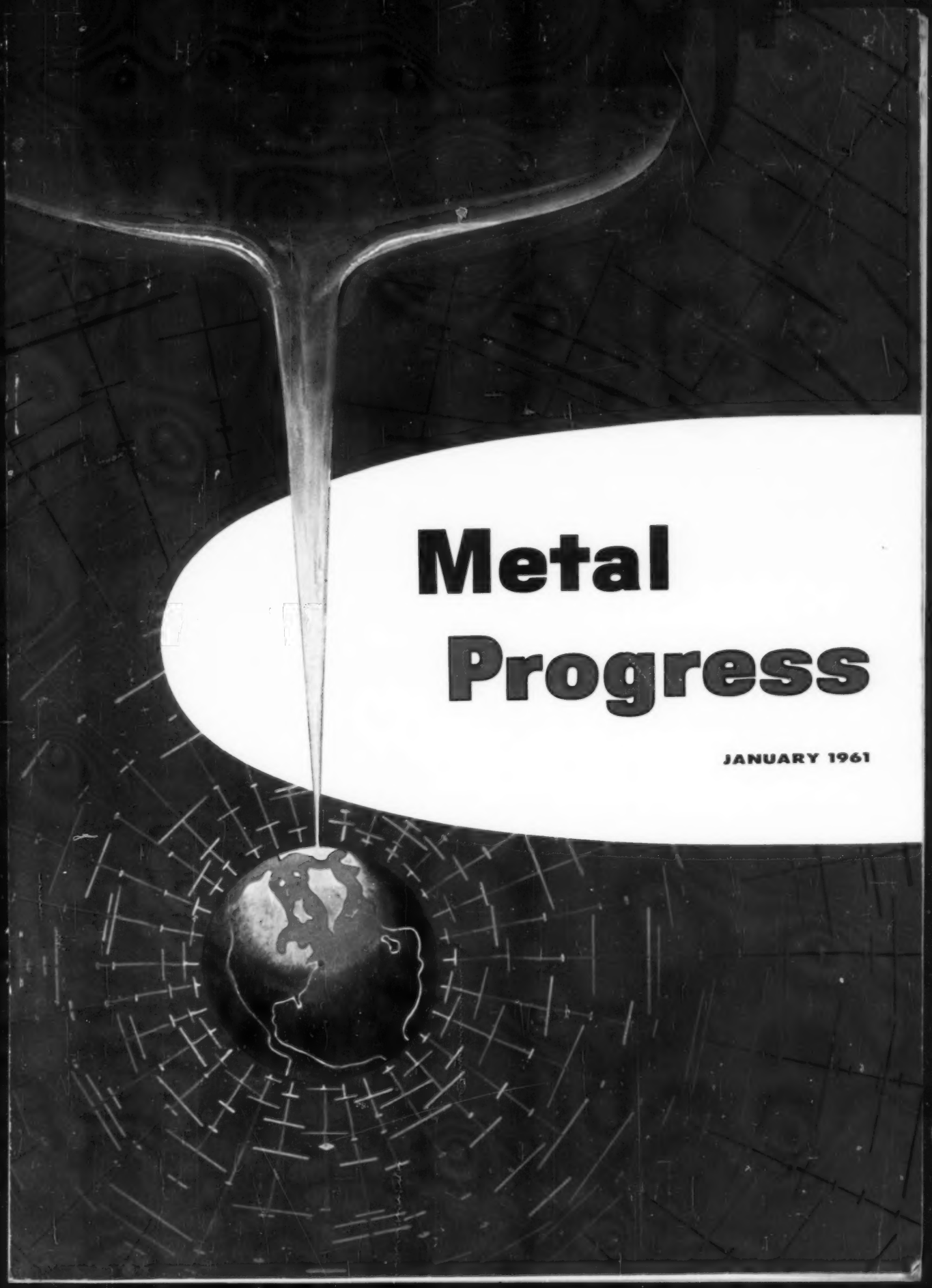

Metal Progress

JANUARY 1961

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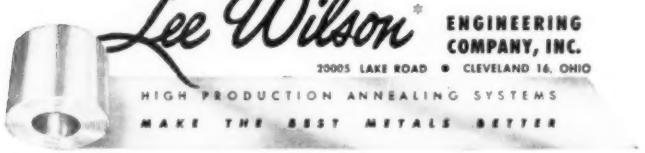

* ORIGINATORS AND LEADING PRODUCERS OF OPEN COIL AND SINGLE STACK FURNACES

Circle 425 on Page 48-B

Metal Progress

January 1961 . . . Volume 79, No. 1

A prizewinner in the annual competition at the Cleveland Institute of Art, this cover designed by ROBERT IRAN illustrates the international theme of the January issue.

Technical News in Brief

German Degassing Process Unveiled . . . Welded Titanium Coils Heat Acid Solution . . . High-Temperature Alloys Used for Tooling . . . Intermetallic Compound Shows Unusual Magnetic Behavior . . . Changes in West Germany Strengthen Its Industry . . . Large Oxygen Unit Serves Openhearth Furnaces . . . Quality Competition Leads to Improved Stainless Strip . . . Trends in Engineering Education in Canada . . . New Alloy for Steam Power Plants . . . Progress in Nonmetallic Materials 65

Technology Forecast '61

Problems and Prospects in Metals and Metalworking 68-A

International Progress in Metallurgy and Metal Working

New Carburizing Steels in German Automobiles, by H. U. Meyer 70

Comprehensive research into the nature of case hardenability has led to the development of carburizing steels in which the major alloying element is molybdenum. These new steels have been successful to the point where they have replaced standard carburizing grades in German automobiles despite their higher cost. (J28g, J5, 2-60; AY, *Mo*)*

Creep Testing Machine Meets British Emergency, by H. Robson 76

Faced with the urgent task of checking the creep properties of numerous forgings of doubtful quality, engineers at D. Napier & Son Ltd. in London designed and built a creep tester in only five weeks rather than cut jet engine production. Simple in design and fabrication, the tester can handle up to six creep specimens at one time. (Q3, 1-53)

How the Russians Are Using Ultrasonics in Metallurgy, by Arthur B. Tesmen 79

In the Soviet Union, ultrasonic energy is being used to degas molten metals, speed diffusion processes (such as carburization), accelerate aging of aluminum alloys and improve weld quality. Other work with ultrasonics is also being done. (D9, E25n, J-general, 1-74)

International Figures in the History of the Man-Made Metal Plutonium, by Arthur S. Coffinberry 84

An outline of work done in various laboratories in the United States, Canada, England, France and Russia, giving credit to the principal scientists and metallurgists. (A-general, A2; Pu)

Large Steel Castings for Heavy Duty, by Heinz W. Balster 89

Basic electric furnaces with capacity over 25 tons and with induction stirring are used for alloy steels. A Cr-Mo-V analysis similar to Type 316 has been widely used for high-temperature service, and 13% Cr steel is favored for corrosion resistance. Welding of simple shapes into complex assemblies is common practice. (E-general; ST, AY, SS)

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**The coding symbols refer to the ASM-SLA Metallurgical Literature Classification, International (Second) Edition, 1958*

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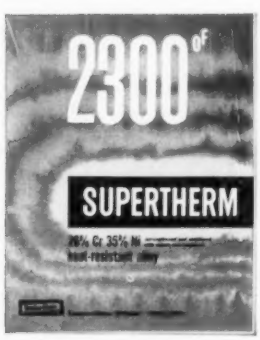

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Metal Progress

Program Control for Forging Press and Manipulator, by Tom Bishop 94

Magnesium Castings in Europe, by E. Sayles 97

Pressure die casting in water cooled molds gives sound parts of excellent surface at high production rates. Other manufacturing advantages make them competitive with aluminum where weight or inertia are important considerations. (T-general, 17-57; Mg-b, 5)

Centenary of the German Metallurgical Society, by Kurt Thomas 103

Although it has a comparatively small membership, Verein Deutscher Eisenhüttenleute is extraordinarily active in German educational and standardization activities, and through its publications – 30% of which circulate abroad – has had unusually large influence on the international scene. (A12g, A2; Fe, ST)

Status of Welding Processes in Europe, by Maximilian Komers 107

Notable progress has been made in the production of strong, tough steels of good weldability, and in devising various schemes for delivering powdered flux and protective atmospheres simultaneously to the arc. Electroslag welding is still under experimental study. (K1)

Decorative Plating Abroad, by A. C. Benning 113

Although some electroplaters still rely on buffed copper-nickel-chromium systems for decorative parts, many have adopted plating practices such as duplex nickel and crack-free chromium which were developed in this country. (L17, T21; *Cr, Ni*)

Metallurgical Progress in Canada, by Harold J. Roast 117

Information from more than a score of laboratories and research departments indicates vigorous advances in all branches of metallurgy, from ore beneficiation to production of dislocations in whiskers, and from steel manufacture to atomic energy. (A-general)

Improved Metallographic Techniques in Nova Scotia, by C. A. Godden 121

Described are a vacuum deposition technique that aids the study of thin oxide films and a versatile mounting material, diallyl phthalate, which does not shrink from edges of the specimen. (M20; Al, 14-62)

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Red Cloud in the East 69

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British Magnesium Alloys 100-B

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Stress-Relieving Large Weldments by Radiant Heating, by Tom Bishop 124

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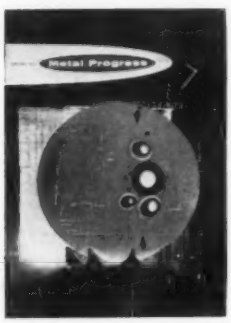
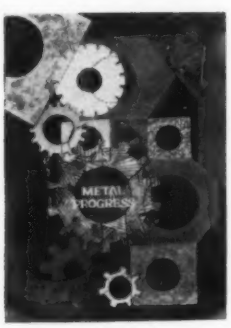




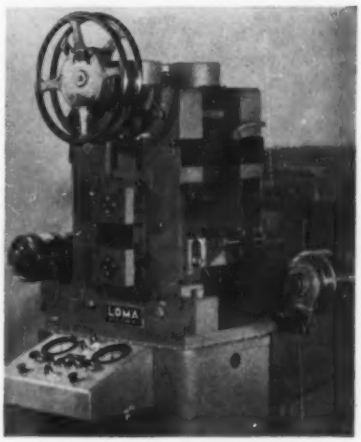
The four *Metal Progress* covers pictured in miniature at the left are the top winners of the dozen judged in our cover contest held at the Metal Show in Philadelphia. First started four years ago, this contest has become an annual feature at the A.S.M. booth. A dozen or so *Metal Progress* covers are displayed—some have already appeared on past issues or are scheduled for a forthcoming magazine, while others are art work for possible future covers, designed by students at the Cleveland Institute of Art in the cover design contest sponsored each year by *Metal Progress*. Visitors to the booth judge the covers (each marked by number) and list their preference; the winner is the one whose list corresponds most closely to the total ballot preference. This year's winner (out of more than 1,600 entries) is ASMer Lawrence Redmersky of Crucible Steel Co.—who received an attaché case.

An interesting outcome of this year's contest is that the *Metal Progress* editors and the booth visitors seem to agree on what makes a good, eye-catching cover. First choice of the contestants was the striking September cover (top, left), while second place was taken by next month's cover—a photograph of a stainless cryogenic pressure vessel emerging from a stress-relieving furnace. The fourth choice shown at bottom probably looks the most familiar—it's on this month's issue. As for the third cover, you may see that on a future issue.

One of the noteworthy features of the October Metal Show issue of *Metal Progress* each year has been the Digest section, containing abstracts of the A.S.M. *Transactions* papers presented at the technical sessions of the Metal Show. This year *Transactions* paper digests will be presented throughout the year (rather than in October only) so that new and important technological information will be available to our readers sooner. Several will be included in next month's issue.

THE EDITORS

NEWS FROM
LOMA



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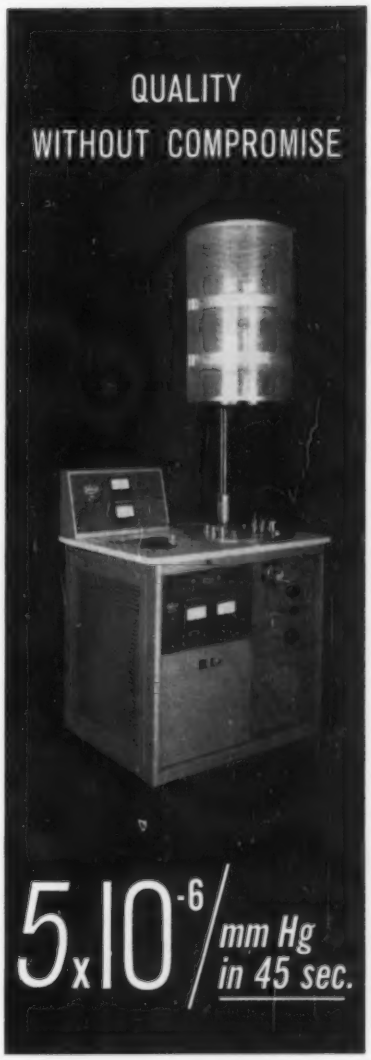

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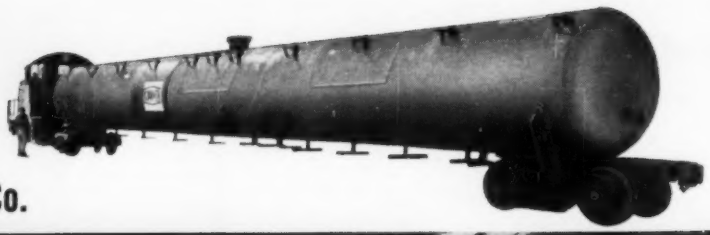

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Circle 528 on Page 48-8

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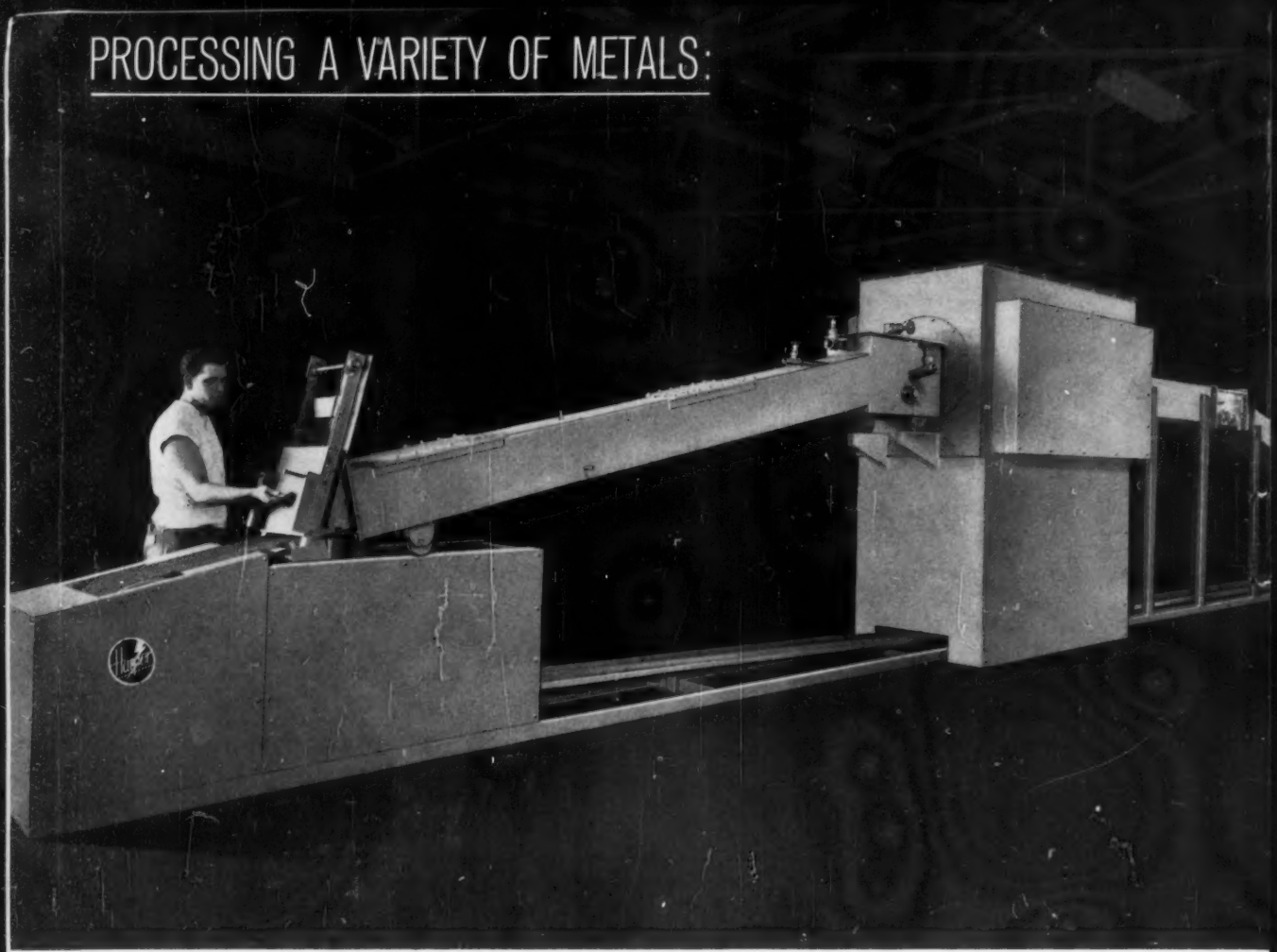

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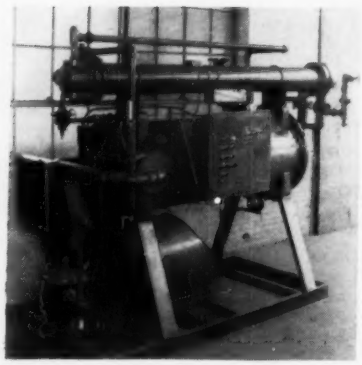
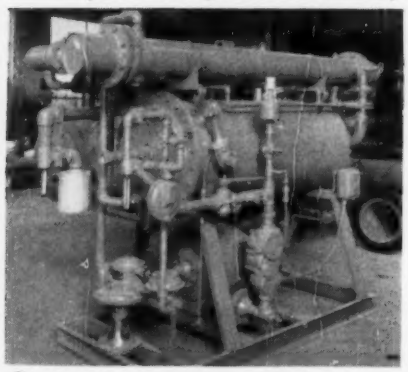
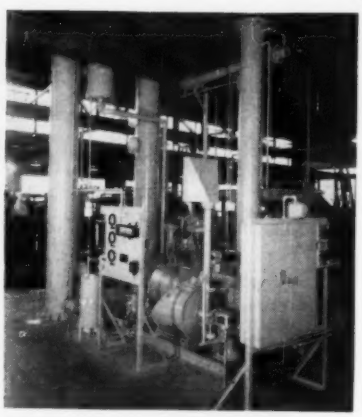


1 KEMP INERT GAS GENERATOR
—for working non-ferrous metals. Produces inert gases for use at low or high pressure, desiccated or unprocessed. Kemp gives you low-cost gas generation, completely automatic operation. Premixing in exclusive Kemp Carburetor and constant analysis assures highest thermal efficiency.



2 KEMP ATMOS GAS GENERATOR
—for working low-carbon steels. For gases low in carbon dioxide. As in all Kemp Gas Generators, test burner permits checking for proper combustion characteristics before igniting burners. Another safety feature: automatic fire-checks guard against flashback.

3 KEMP NITROGEN GENERATOR
—for working high-carbon steels. Completely eliminates CO_2 from gas, produces 99+% nitrogen. Features the easy start-up typical of all Kemp Generators. Vernier dial can be locked in position to maintain exact fuel-air ratio without further control manipulation.



The Kemp representative in your area can advise you on the type and size of generator to best solve your problem. Talk to him or write: The C. M. Kemp Manufacturing Company, 405 E. Oliver St., Baltimore 2, Maryland.

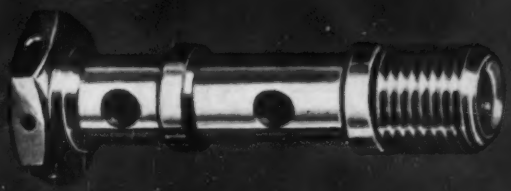
It always pays to come to

KEMP OF BALTIMORE

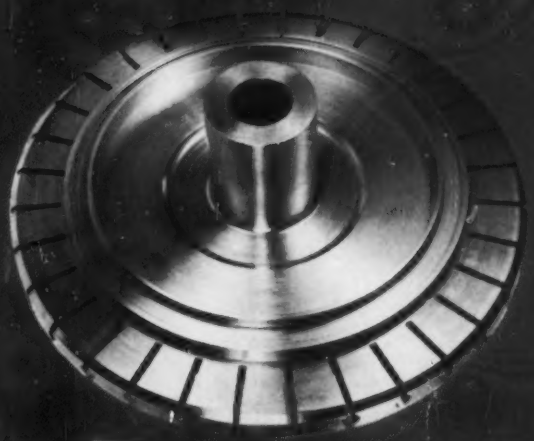
THE C. M. KEMP MANUFACTURING COMPANY
405 E. Oliver St., Baltimore 2, Md.

Circle 532 on Page 48-B

you can drill it...



you can machine it...



you can head it...

but you can never, no never, change its **consistent uniformity!**

...your first order will convince you—**Carpenter Specialty Stainless** is easier to fabricate. Made by one of the leading producers of stainless steels for industry, Carpenter Specialty Stainless assures greater output, fewer rejects and increased profits.

Carpenter steel

you can do it ***consistently*** better with Carpenter Stainless Steels for specialists

Circle 533 on Page 49-S

The Carpenter Steel Company, Main Office and Mills, Reading, Pa.
Alloy Tube Division, Union, N. J.
Webb Wire Division, New Brunswick, N. J.
Carpenter Steel of New England, Inc., Bridgeport, Conn.

THE NEW AB

POWERMET PRESS

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- PUSH BUTTON CONTROLLED
- POWER OPERATED
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- CONTROLLED MOLDING PRESSURE
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- QUALITY COMPONENTS USED
- CONFORMS TO J.I.C. STANDARDS

Buehler Ltd.

METALLURGICAL APPARATUS

2120 GREENWOOD ST., EVANSTON, ILLINOIS, U.S.A.

Circle 534 on Page 48-B

METALGRAMS

UNION CARBIDE METALS

. . . news of "Electromet" ferroalloys and metals

JANUARY, 1961

CLEANER STEELS-HIGHER QUALITY -- "Silicomanganese deoxidation in the furnace produced average cleanliness better than any other furnace practices tried," the 1957 Open Hearth Conference was told. The cleaner steel produced with silicomanganese additions has better surface quality and mechanical properties. Silicomanganese not only produces fewer inclusions, but also forms more desirable inclusion types. Other advantages: improved forging and rolling properties, lower conditioning costs, and increased mill yield.

* * *

DATA FAVOR SILICOMANGANESE -- Production data has shown that lowest scarfing costs are obtained with a heavy silicomanganese block. Silicomanganese also reduces hot shortness of some high-sulfur steels and generally improves the quality of other steels. Long internal seams that cause rejections in the finished product are also reduced with a silicomanganese block. Have your Union Carbide Metals representative show you how you can improve the quality of killed steels used for all applications. Also, ask for the article, "Silicomanganese Produces Cleaner Steels", in the Winter 1961 issue of UNION CARBIDE METALS REVIEW.

* * *

LOW COSTS WITH CHARGE CHROME -- In recent years, the use of charge chromes in stainless steel melting has increased markedly. The reason: they are the lowest-cost ferrochromes available. Union Carbide Metals offers three alloys with different chromium, carbon, and silicon contents to meet individual practices. UCM's studies using a high-speed computer have helped steelmakers select the charge chrome that will give lowest costs. Look to Union Carbide Metals for help on the most economical use of charge chrome alloys. For more information, write for the article, "Predicting Minimum Materials Cost for Stainless Steel", in the Spring 1959 issue of UNION CARBIDE METALS REVIEW.

* * *

WHY BUY AMERICAN? -- Ferroalloy imports doubled between 1955 and 1959. Steel, iron, and nonferrous imports are up sharply too! Foreign producers have low wage rates which enable them to compete on a price basis with the U. S. However, they cannot compete with U. S. producers on three counts: (1) valuable metallurgical assistance at a user's plant, (2) consistent quality in all materials, and (3) products delivered when the customer wants them. For further information, write for the article, "Why Buy American?", in the Fall 1960 issue of UNION CARBIDE METALS REVIEW.

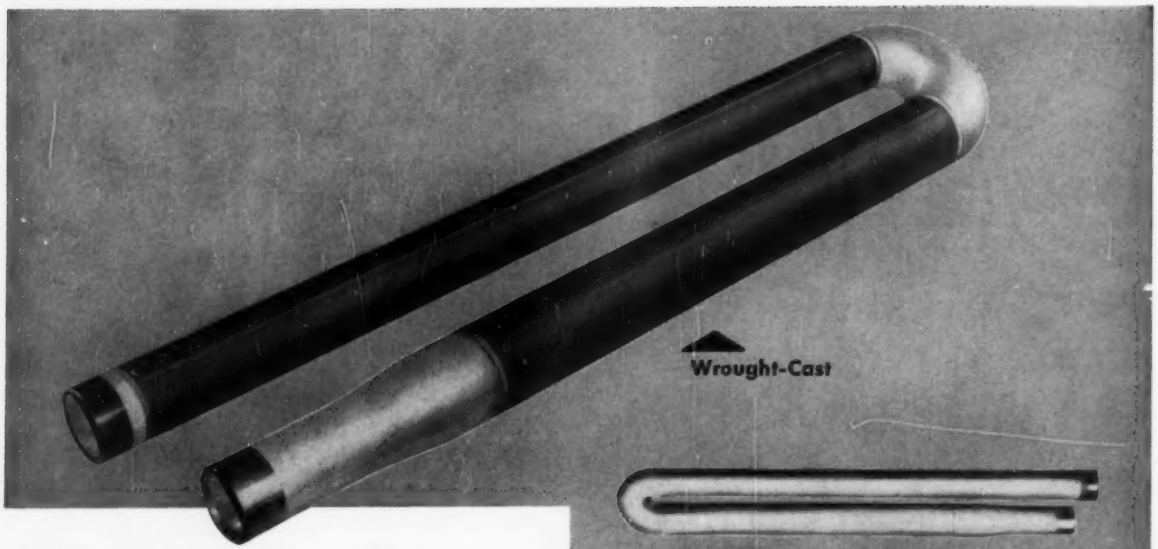
* * *

MANGANESE IN ALUMINUM -- In binary alloys, manganese improves the strength of aluminum by 20 per cent with no sacrifice in corrosion resistance. Thus, 3000 series alloys (containing 1.25 per cent manganese) are good general-purpose alloys for storage tanks, piping, furniture, TV antennas, awnings and siding, and chemical equipment. Manganese is also added to 2000, 5000, and 6000 series alloys to improve corrosion resistance. UCM offers low-iron ferromanganese and "Elmang" electrolytic manganese for such additions. More information can be obtained by writing for the article, "Manganese Puts Muscle in Aluminum", in the Winter 1961 issue of UNION CARBIDE METALS REVIEW.

* * *

UNION CARBIDE METALS COMPANY, Division of Union Carbide Corporation, 270 Park Avenue, New York 17, N. Y. In Canada: Union Carbide Canada Ltd., Toronto.

"Electromet," "Elmang," and "Union Carbide" are registered trade marks of Union Carbide Corporation.



All Cast

Unique General Alloys'

WROUGHT-CAST RADIANT TUBES

give consistent long life

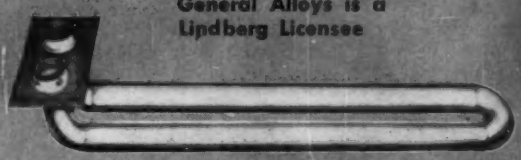
General Alloys' combination *Wrought-Cast* Radiant Tube Assemblies give consistent long life because they combine a *cast* return bend with straight tubes made from *rolled and welded plate.*

This design utilizes the erosion resistance of the casting where it is most needed . . . at the return bend. The uniform wall section of the plate forming the straight tube, and its smooth interior surface, prevent "hot spots" and "carbon build-up" that are the prime causes of erratic tube life.

General Alloys Company is unique as a major producer of *both* castings and fabrications and therefore can recommend, without bias, the type of construction best suited for your needs.

For complete data, quotes, or engineering service contact the office nearest you . . . or write General Alloys Company, 401 West First Street, Boston 27, Massachusetts.

Lindberg Furnace Tube
General Alloys is a
Lindberg Licensee



All Fabricated

General Alloys Company also produces entirely cast, as well as entirely fabricated radiant tube assemblies, in all the heat resisting alloys for every purpose and in every size.

Ask about how our tube repair service can save you money!

GENERAL ALLOYS CO.

the only producer of both heat resisting castings and fabrications

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Associated Steel Mills, Inc.
P.O. Box 1986, Meramec Station

Circle 535 on Page 48-B

Model 500-40 VS
(500 amp rated output)

For jobs where only the best will do—

NEW GLENN V/S VARIABLE SLOPE CONSTANT VOLTAGE POWER SUPPLIES

for all consummable-electrode automatic and semi-automatic welding processes, including:

MIG - SHORT ARC
SUBMERGED ARC - MAGNETIC FLUX

New GLENN V/S power supplies are totally new from basic transformer design to their exclusive new linear slope control. They can be precisely "tuned" to the exact arc characteristics needed to produce any type of metal transfer and deposition desired. The result is improved weld quality, appearance, speed and economy.

Model 300-40 VS
(300 amp rated output)

Basic features

1. **NEW TRANSFORMER DESIGN** increases efficiency, improves voltage regulation and minimizes effects of line voltage fluctuations.

2. **STEPLESS VERNIER SLOPE CONTROL** provides continuous linear slope control from flat no-slope to maximum slope; in two overlapping ranges.

3. **EXTENDED OUTPUT VERNIER VOLTAGE RANGE** provides effective dc welding (loaded) voltages from approximately 8 to 42 volts, depending on slope settings.

WHEN SPECIFICATIONS ARE CRITICAL and weld quality, uniformity and appearance must be kept high, you'll be hours and dollars ahead to specify GLENN V/S power supplies. Why not get the facts? Write us today for literature, specifications; please address Dept. 136

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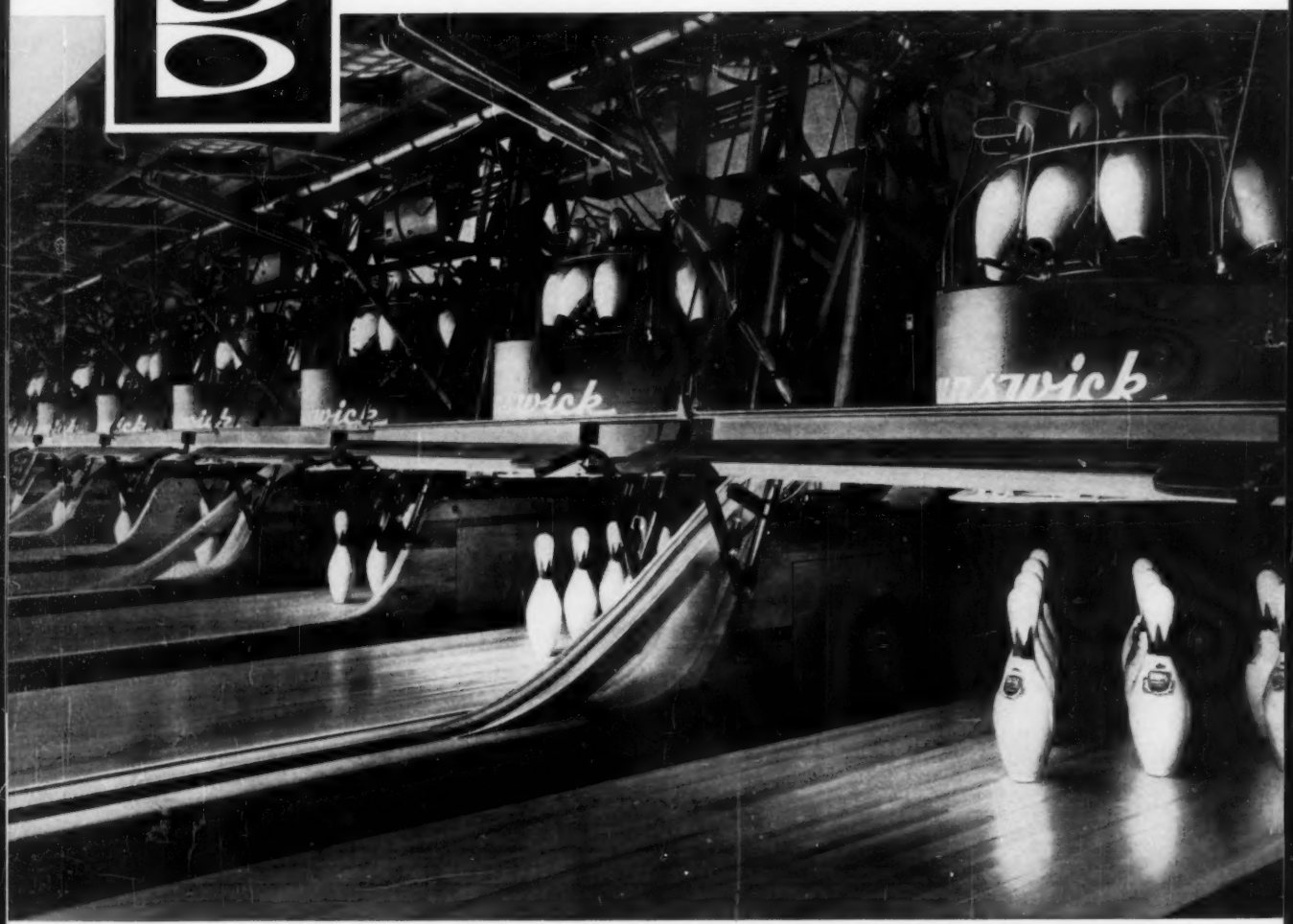
✻ GLENN Balanced Wave Power Supply for TIG Welding ✻ GLENN Manual and Stud Welder Power Supply ✻ GLENN Arc Gouger Power Supply ✻ GLENN Constant Potential Welder for "Gang" Manual Welding ✻ GLENN Industrial Power Supplies and Heavy Duty Variable Voltage Transformers

Circle 481 on Page 48-B

Brunswick CORPORATION

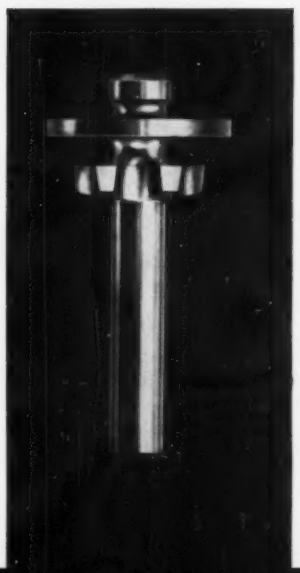
puts "Mechanical Brain" to work



CENTURY SERIES C-1144 Distributor Shaft
CENTURY SERIES C-1141 Hoist Support Shaft
CENTURY SERIES C-1151 Electric Motor Shaft
CENTURY SERIES C-1050 Axle
CENTURY SERIES C-1045 Shaft

HIGH MACHINABILITY is the reason Republic ENDURO® Stainless Steel, Type 303, was selected by the National Acme Company in producing one-piece Hyseal Valve Stems for the new American-Standard single-lever mixing faucet. Ten operations, including a multiple end drilling of six holes on a 15° angle are performed in just 12 seconds in a single setup. Write for information on the more than 40 types of Stainless Steel available from Republic. Use coupon.

SPECIFY DEGREE OF MACHINABILITY. Select from Republic's CENTURY SERIES of high strength, stress-relieved, cold finished steel bars. Five grades: C-1045, C-1050, C-1151, C-1141, and C-1144. Each offers minimum yield strength of 100,000 psi. For parts needing little machining, better strength-to-toughness ratios are often obtained with one of the less expensive, lower sulphur grades. Send for your free copy of Republic's CENTURY SERIES Booklet.



with ELECTRUNITE Mechanical Tubing

Better bowling by Brunswick. Better automatic pinsetting with ELECTRUNITE. That's the story behind today's most popular participation sport—bowling for the entire family.

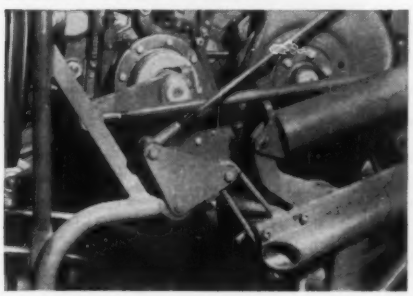
The Automatic Pinsetter, designed and produced by the Brunswick Corporation, Bowling Division, Chicago, Illinois, is a precision engineered, rugged, mechanical unit designed to set pins, sweep away "deadwood" and reset remaining pins, all in the matter of seconds, automatically.

Republic ELECTRUNITE Mechanical Tubing was specified because it met the extreme tolerance requirements with a substantial savings in weight. No sacrifice in strength. High quality ELECTRUNITE is delivered ready for fabricating. Excess manufacturing costs squeezed out.

Republic, world's largest producer of specialty welded tubing, offers ELECTRUNITE in a wide range of sizes, gages, and wall thicknesses, supported by technical and metallurgical assistance. Prompt price and delivery quotations usually within twenty-four hours. Call your Republic representative. Or, write direct. Use coupon below.

In just 12 seconds, the Brunswick "Magic Brain" sets up the alley for the next shot. The ball takes an elevator ride on ELECTRUNITE Mechanical Tubing to start the return trip to the bowler.

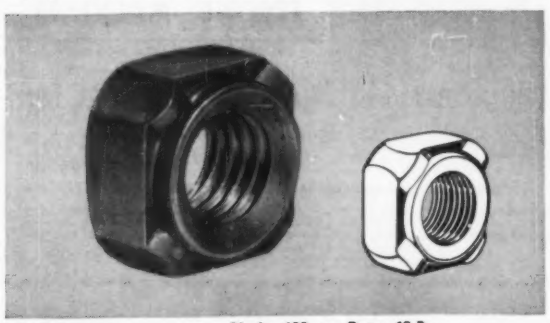
When the ball hits the hinged pit cushion the motion is mechanically transferred to trigger the machine cycle. ELECTRUNITE Mechanical Tubing is used for the pit cushion support arms construction.



ELECTRUNITE Tubing in three key locations assures smooth, trouble-free lifting, sweeping, Automatic Pinsetter operation. ELECTRUNITE is delivered ready for fabricating, saving production time and costs.

ELECTRUNITE was specified by Brunswick because it meets the extreme tolerance requirements, eliminating the need for any additional machining operations.

REPUBLIC MIDLAND WELD NUT is the newest addition to the more than 20,000 different types and sizes of Republic Fasteners. Republic Weld Nuts save time and money, solve difficult design and assembly problems. Applied quickly and easily by any standard projection welding machine of proper capacity. Fast, accurate positioning. Positive weld. Sure holding power. Ideal for the fabrication fastening, or assembly of metal parts. Write for additional data.



Circle 482 on Page 48-B

REPUBLIC STEEL

World's Widest Range of Standard Steels and Steel Products

REPUBLIC STEEL — Strong, Modern, Dependable — Steel

REPUBLIC STEEL CORPORATION
DEPT. MP-1600
1441 REPUBLIC BUILDING • CLEVELAND 1, OHIO

Please send more information on the following products:
- ☐ ELECTRUNITE® Mechanical Tubing
- ☐ Republic Midland Weld Nuts
- ☐ Republic ENDURO® Stainless Steel
- ☐ CENTURY SERIES Booklet

Name_____ Title_____

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to bring your testing machine file up to date...

New bulletins* to help keep you informed about today's modern testing equipment are being offered by Riehle Testing Machines. To up-date your reference file with this new technical information, check the list below and clip it to your letterhead. Literature you request will be sent promptly.

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- ☐ Brinell Hardness Testers
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- ☐ Portable Hardness Testers for Rockwell Readings
- ☐ Hardness Conversion Chart for Hardened Steels
- ☐ Impact Testing Machines
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- ☐ Cable and Wire Testers
- ☐ *Calibration Catalog
- ☐ Handsome wall plaque, reading: "One Test is Worth a Thousand Expert Opinions."™

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A DIVISION OF

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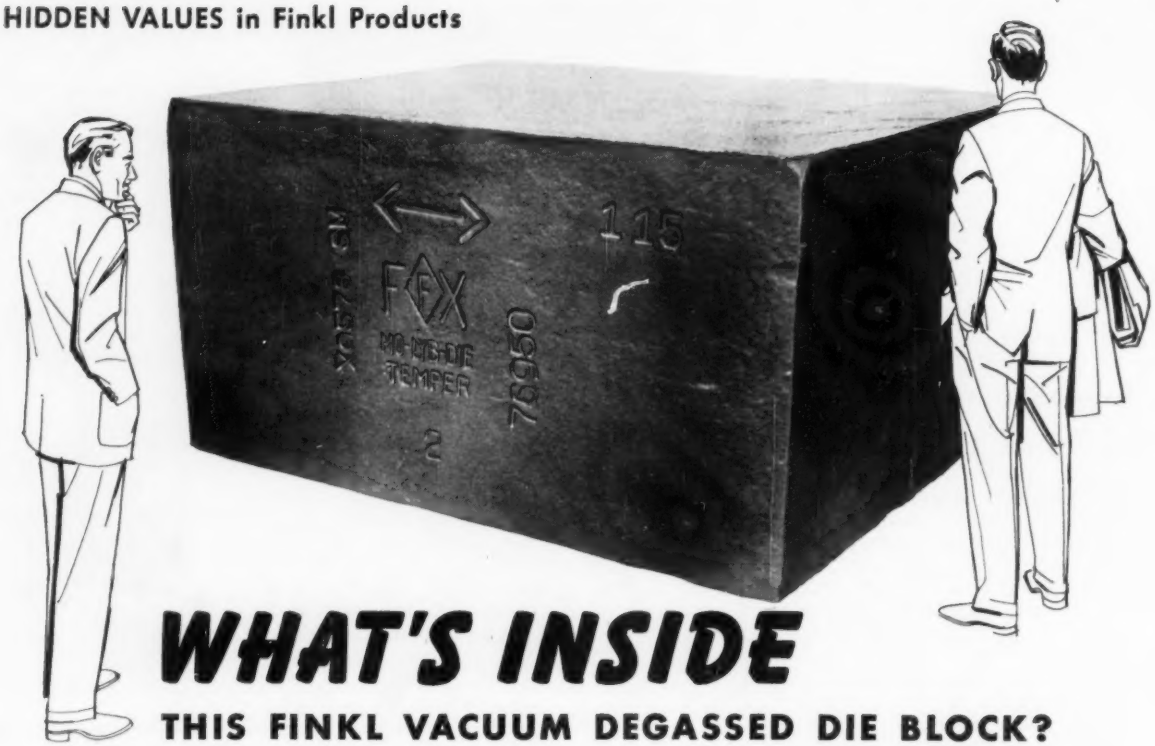
NEW PRODUCTS • NEW PRODUCTS • NEW PRODUCTS •

HIDDEN VALUES in Finkl Products



WHAT'S INSIDE

THIS FINKL VACUUM DEGASSED DIE BLOCK?

There are connecting rods, track links, outboard crankshafts, forged products of aluminum, magnesium, titanium, and a myriad of hot work applications.

There is excellent machineability, fewer tool regrinds, and higher luster in the impression because more than half of the oxidic inclusions and other impurities have been removed.

There is increased forging production with less downtime due to breakage, even under severe operating conditions. This is due to the higher density steel which has been purged of over half of its hydrogen and oxygen—the troublesome gases.

There is the value of over eighty years of experience in the manufacture of forgings, die blocks, and hot work steels.

There is the value of strict quality control through every step from the processing of our own electric furnace steels to the final "okay" in the ultrasonic testing department.

You get more from Finkl in quality products, continuing research, and engineering service. Call your Finkl representative for your forging, hot work die steel, and die block needs.

This mark tells you a product is made of modern steel.

Write to Dept. C, on your company letterhead for free BULLETIN 200. It tells how to care for and get more production out of your Finkl die blocks.

SPECIFY FINKL DIE BLOCKS AND HOT WORK STEELS FOR "IMPRESSIONS THAT LAST"

HOT WORK STEELS · DIE BLOCKS · FORGINGS · ELECTRIC FURNACE STEELS

A. Finkl & Sons Co.

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Offices in: DETROIT • CLEVELAND • PITTSBURGH • INDIANAPOLIS • HOUSTON • BOSTON
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LOS ANGELES Warehouses in: CHICAGO • DETROIT • BOSTON • LOS ANGELES

Circle 484 on Page 48-B

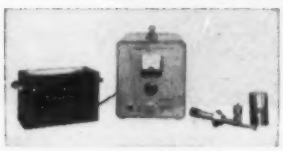
Cleaning and Finishing Equipment

Color Coating for Metals

Revealed at the Metal Show, a new chromate surface treatment, "Hinac Process," color coats ferrous and nonferrous metals in a single treatment. The aqueous solution is applied at room temperature by roller coating, dipping, or spraying; contact time is only a few seconds. The coating is cured by heating to about 375° F. for 10 sec. Available in red, brown, green, blue, black, gray and bronze, the attractive, adherent finish is resistant to most acids, alkalies, solvents, and oxidizing agents. *Pennsalt Chemicals Corp.*

For further information circle No. 206 on literature request card, p. 48B

Versatile Ultrasonic Generator



With a selection of ten output impedance values, the "Inson 100 PW" generator can be utilized in cleaning, drilling, welding, soldering, splicing, and sealing of metals and plastics. The power output is continuously variable from zero to full power (100 watts), and frequencies from 10 to 100 kc. may be specified. The standard 40 kc. unit, with an impedance range from 17.5 to 20,000 ohms, may be coupled with either piezoelectric or magnetostrictive transducers. *International Ultrasonics, Inc.*

For further information circle No. 207

Non-Electroplated, Adherent Copper Coating

The "Cuprodine No. 5" process provides increased coating adherence and color uniformity, compared to sulphuric acid-copper sulphate formulations, when applied to carbon and stainless steel wire and stampings. The thin, adherent copper coating acts as a lubricant in reducing scratching of the wire, pickup, and die wear. For tire bead wire, the coating provides a good bonding surface for the rubber. The Cuprodine process is useful for color coding parts and as a decorative finish. *Amchem Products, Inc.*

For further information circle No. 208 on literature request card, page 48B

Ultrasonic Cleaning System

Intricate parts and sub-assemblies, which are inaccessible to other cleaning methods, are easily cleaned with the "Model LG-75" ultrasonic cleaner. Transistors are employed in the compact 75-watt, 25 kc. generator for maintenance-free operation. The full-wave output signal—which removes even stubborn stains rapidly and thoroughly—can be switched quickly from cleaning to rinse tank operation. Optional heating elements produce temperatures to 200° F. *Branson Ultrasonic Div.*

For further information circle No. 209

Chromate Conversion Coating

For applications requiring an improved corrosion protection over zinc plate, a chromate conversion coating called "MacroBrite 2" may be used. The product – an acid salt which produces a bright finish with the blue tint of chromium – replaces a nitric acid bright dip. This single immersion treatment gives more uniform results, better control, and improved corrosion resistance. *MacDermid Inc.*

For further information circle No. 210

Welding and Joining Equipment

Welding Thin Metals

Metal as thin as 0.001 in. can be welded at speeds up to 300 spots per min. Welding pressure can be adjusted from a few ounces to 60 lb., and by overlapping the spots a hermetic seal-weld can be made. The manually or automatically operated unit can be adjusted to produce a ring of welds up to 6 in. in diameter. *Statham Instruments.*

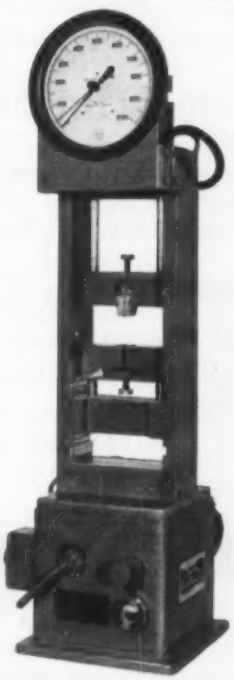
Circle No. 211 on card

Tensile Testers

• Motorized • Bench-Mounted
• Easy-to-Operate • Low Cost
Capacities from 1,000 to 20,000 lbs.

Available in two general sizes that occupy minimum space and provide consistently accurate and dependable results. Simple, easy-to-use controls are conveniently located on front of base. Jaws are quickly changed to accommodate specimens of different sizes. Operation is hydraulic; powered by 1/6-hp. 110-v motor. Load gage is protected from specimen-fracture shock by rubber mount. Twin load gages and floor stand are available as optional equipment.

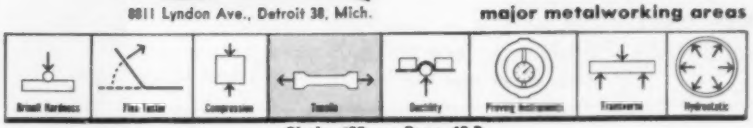
Write or call if you have any special testing problem



These machines are designed to also perform compression tests.

Steel City Testing Machines Inc
8811 Lyndon Ave., Detroit 38, Mich.

Distributors in most major metalworking areas



Circle 485 on Page 48-B

YOUR ONE, COMPLETE SOURCE FOR HIGH TEMPERATURE HIGH STRENGTH METALS IN ALL FORMS

Complete Production Facilities

All the tools to do the job are here—all types of vacuum melting and electric arc furnaces, complete rolling and forging equipment. You can get the highest quality mill products—billets, bar, wire, sheet, strip and plate to *your exact specifications.*

Extensive Research and Development

Universal-Cyclops modern research facilities include pilot plant operations and the most modern testing equipment. From Universal-Cyclops has come such well known alloys as Unitemp 19-9 DL, Unitemp N155, Unimach I, and Unimach UCX2. Present alloy development programs will lead to other useful metals.

Geared for Fast Service

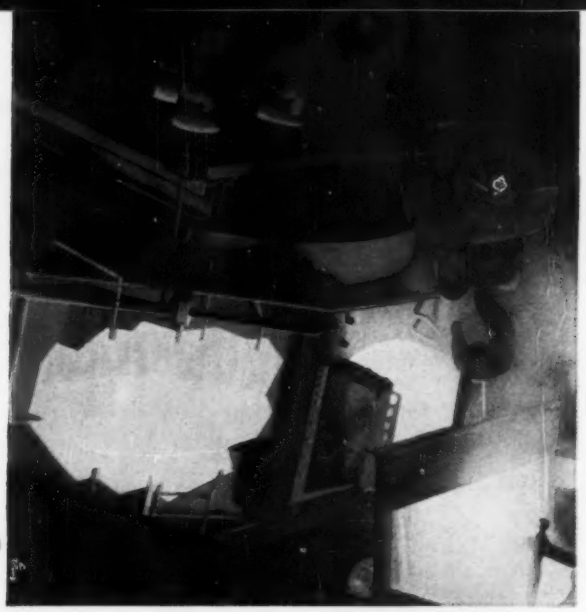
Call your nearest Universal-Cyclops District Sales Office for dependable service on Unitemp high temperature metals and Unimach high strength steels.

Melting Furnaces Illustrated

① Electric Arc, Precision Air Melting

② Inductovac®, Induction Vacuum Melting

③ Duomelt®, Consumable Electrode Vacuum Melting —And Duovac® (not illustrated)—combining processes 2 and 3.



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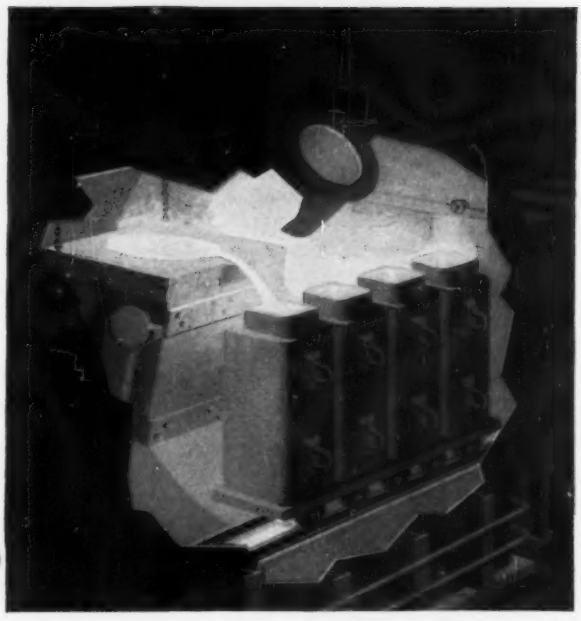

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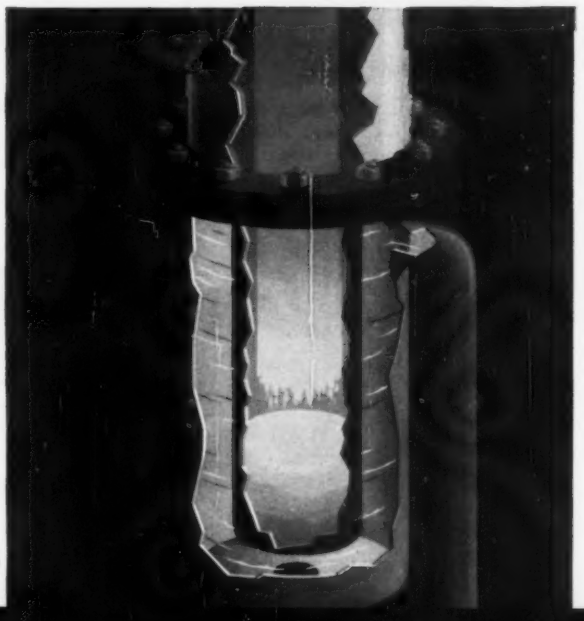

③

UNIVERSAL CYCLOPS
UC STEEL
STEEL CORPORATION
EXECUTIVE OFFICES: BRIDGEVILLE, PA.

HIGH TEMPERATURE METALS • STAINLESS STEELS
TOOL STEELS • REFRACTORY AND REACTIVE METALS

Circle 486 on Page 48-B

Silicon Rectifier Welder

A 500-amp. a-c./d-c. welder with a 100% duty cycle – the first in the industry – is designed to replace 600-amp. motor-generator sets for semi-automatic, submerged arc welding applications, including heavy metal fabrication. The machine's a-c. section is suitable for use with heavy, iron-powder electrodes. The d-c. side is utilized where hand arc-welding is required. *A. O. Smith Corp.*

For further information circle No. 212 on literature request card, p. 48B

Heavy-Duty Automatic Torch

The "Model Q-5" is designed to automatically groove seams and prepare edges of heavy plate for welding. Its fast travel speed and low heat input keep plate distortion to a minimum. The tractor-driven automatic head features all-position adjustment of electrode angle and a variable feed for the electrode. A special device maintains a constant distance between the work and the electrode (size range: ¾ to ⅝ in.) Precision grooves of desired depth and contour may be made on either flat work or tanks. *Arcair Co.*

For further information circle No. 213 on literature request card, p. 48B

Carbon Dioxide Welding of Small Wire

This process is particularly adapted to light gage, mild steel welding or all-position welding, employing inexpensive CO_2 and argon mixtures for shielding. Small (0.020 to 0.045 in.) diameter wire is automatically fed to the low-voltage (15 to 24 v.) arc, permitting continuous

duty welding at low currents, 30 to 200 amp. Up to 50% faster welding speeds are obtained, compared to ordinary welding methods. Wide-gap joints, twice the base-metal thickness, can be welded. Costly clean-up time is eliminated; spatter is practically nonexistent. *Hobart Bros. Co.*

For further information circle No. 214 on literature request card, p. 48B

Low-Alloy Steel Electrode

"Speedex 710 Mo," a heavy coated, shielded-arc type of low-alloy steel electrode, is being offered by *Metal & Thermit Corp.* An E7010-Al electrode, it is recommended for high-tensile steel applications, such as high-pressure piping in power plants and refineries, structural fabrication and casting repair. The electrode – available in ⅛, 5/32 and 3/16 in. diameters – is used in all positions. Weld is 10,000 psi. stronger than that made by E6010 electrodes.

For further information circle No. 215

Three-Phase DC Welders

The "Idealarc R3M" series of silicon rectifier arc welders is suitable for general production, structural, or maintenance welding applications. Four sizes are available–300, 400, 500 and 650 amp. at 40 v., 60% duty cycle. Sticking of small diameter electrodes at low currents is impossible. At high amperage, a smooth arc transfer is maintained. Current can be reversed without changing cable connections. *Lincoln Electric Co.*

Circle No. 216 on card

Inspection and Control Equipment

Remote Control Load-Cell System

In applications where site proximity is dangerous or inconvenient, a remote indicating load cell system gives instantaneous, direct readings of force at distances up to

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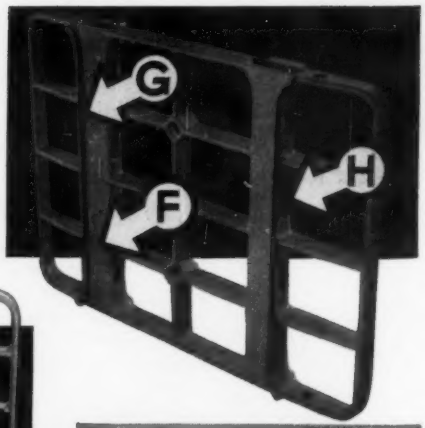
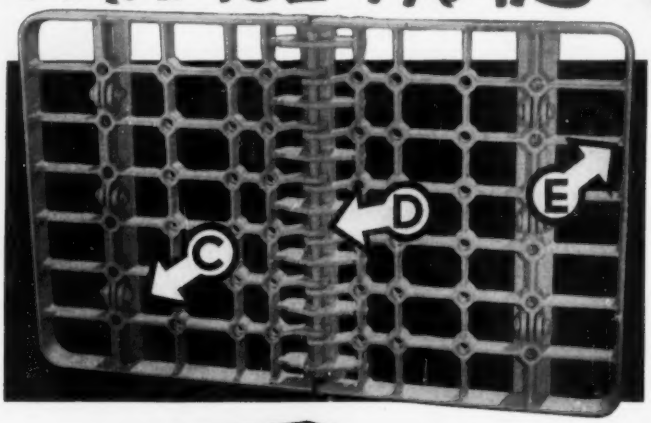
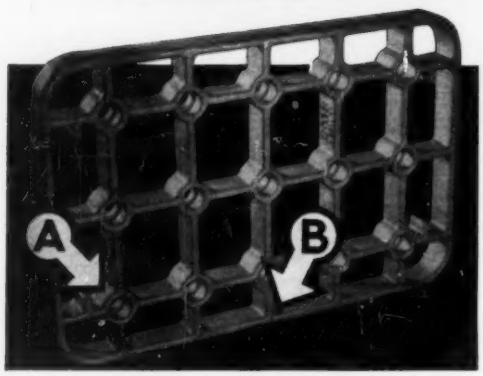
Circle 487 on Page 48-B

ENGINEERING GIVES Better Service ON FURNACE TRAYS







Why DO AECCo. TRAYS CONSISTENTLY GIVE BETTER SERVICE?

- **A** UNIFORM SECTIONS AND BARREL CORES AT INTERNAL INTERSECTIONS — BETTER CASTINGS AND LESS THERMAL STRESS IN USE.
- **B** CONTROLLED FINE GRAIN STRUCTURE AT EXTERNAL INTERSECTIONS—BETTER FATIGUE LIFE ASSURED.
- **C** SHOES PROVIDED FOR RAIL SUPPORTS AS REQUIRED.
- **D** AECCo. PROPRIETARY HINGE DESIGN FOR EQUAL LOADING ON THREE RAIL FURNACE APPLICATIONS.
- **E** FULL RADII EVERYWHERE—NO SHARP CORNERS TO ACT AS NOTCHES FOR FATIGUE FAILURES.
- **F** TUBULAR COMPRESSION MEMBERS AND RAIL SUPPORTS — FOR INCREASED STIFFNESS, AND STRENGTH WHERE STRENGTH IS NEEDED.
- **G** INTEGRAL FLANGE ON TUBE SERVES AS RAIL GUIDE.
- **H** GENEROUS OPENINGS FOR ATMOSPHERE AND QUENCH CIRCULATION CONTRIBUTE TO LONGER LIFE.

Because OF BALANCED DESIGN—ATTENTION TO DETAIL — PROPRIETARY PROCESSES and PRODUCTION KNOW-HOW

FURNACE TRAYS—of all types, sizes, and configurations—are an AECCo. specialty. We treat each tray design and order as an opportunity to apply our experience and knowledge in heat resistant alloys, and to create better HIGH TEMPERATURE TOOLING for the user.

SERVICE RECORDS—in the plants of many customers—confirm that AECCo. furnace trays do a better job and last longer. Note Accoloy Pointers for a few of the details which contribute to these results.

HEAT RESISTANT CASTINGS
ACCOLOY
STAINLESS STEEL CASTINGS

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ENGINEERS AND PRODUCERS OF HEAT AND CORROSION RESISTANT CASTINGS

Career opportunities for metallurgists

Can you qualify for the opportunities that INCO's Research Laboratory offers to metallurgists who are able to plan and conduct research in these fields?

- **Corrosion research** on both ferrous and nonferrous metals and alloys and coated metals, and the fundamental mechanisms involved in corrosion.
- **High temperature research** in developing alloys for service at all temperatures and studying the basic factors that control resistance to deformation.
- **Cryogenic studies** of effects of deep sub-zero temperatures on mechanical properties and behavior of metals.
- **Research on the effects of alloying elements** on ferrous and nonferrous casting alloys to develop new alloys and improve methods of melting and casting.
- **Welding research** to develop new welding rods and techniques for existing and newly-developed alloys.

Requirements: Ph.D. or Sc.D. Also M.S. degree with research experience is acceptable.

More information is given in the current report of INCO Laboratory activities, "Metals Plus Research." Do you want to review a copy?

Director of Research

The International Nickel Company, Inc.
67 Wall Street, New York 5, N. Y.

1000 ft. An inverse ratio circuit eliminates tubes and amplifiers; separate reference charts, conversion tables, and circuit balancing are not required. Accurate within ½ of 1% of full-scale, the load cell systems are available in tensile, compression, or push-pull types in 27 capacities from 0-150 lb. to 0-200,000 lb. *W. C. Dillon & Co.*

For further information circle No. 217

Sheet Metal Tester

The "Ductomatic" tester, which simulates actual deep drawing operations, will predict ductility and forming characteristics of sheet metal. Scrap losses and rework costs are reduced and die life is prolonged. Principal tests include deep-draw hole expansion test and

a deep-draw cupping test, which is the best method for determining drawing limitations. This tester — in capacities from 12,000 to 70,000 lb. — can be used for clamping pressure tests, and in studying adhesion and flexibility of lacquer or paint finishes. *Tinius Olsen Testing Machine Co.*

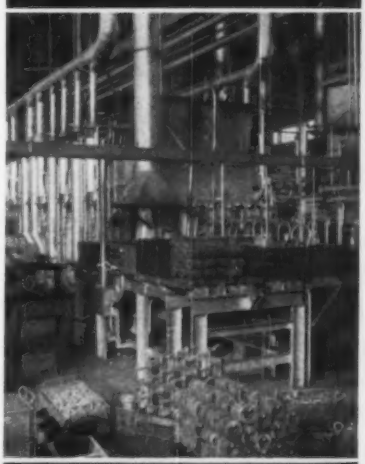
For further information circle No. 218

Adapter Unit for Ductility Testing

The "Model CTC" sheet-metal tester cell adapts existing compression equipment to ductility testing. The *Detroit Testing Machine Co.* claims that tests with this inexpensive unit (on sheet metal up to 1/16 in. thick) are as accurate as those with machines costing three times as much. This self-contained Tester Cell, which weighs only 22 lb., can be used in conjunction with a variety of compression loading equipment for performing ball, punch, and cup-type ductility tests.

For further information circle No. 219 on literature request card, p. 48B

HOLCROFT



Production Heat Treating Equipment

Working with these materials:

- ALUMINUM
- BRASS
- COPPER
- STEEL
- MALLEABLE
- STAINLESS
- CAST IRON

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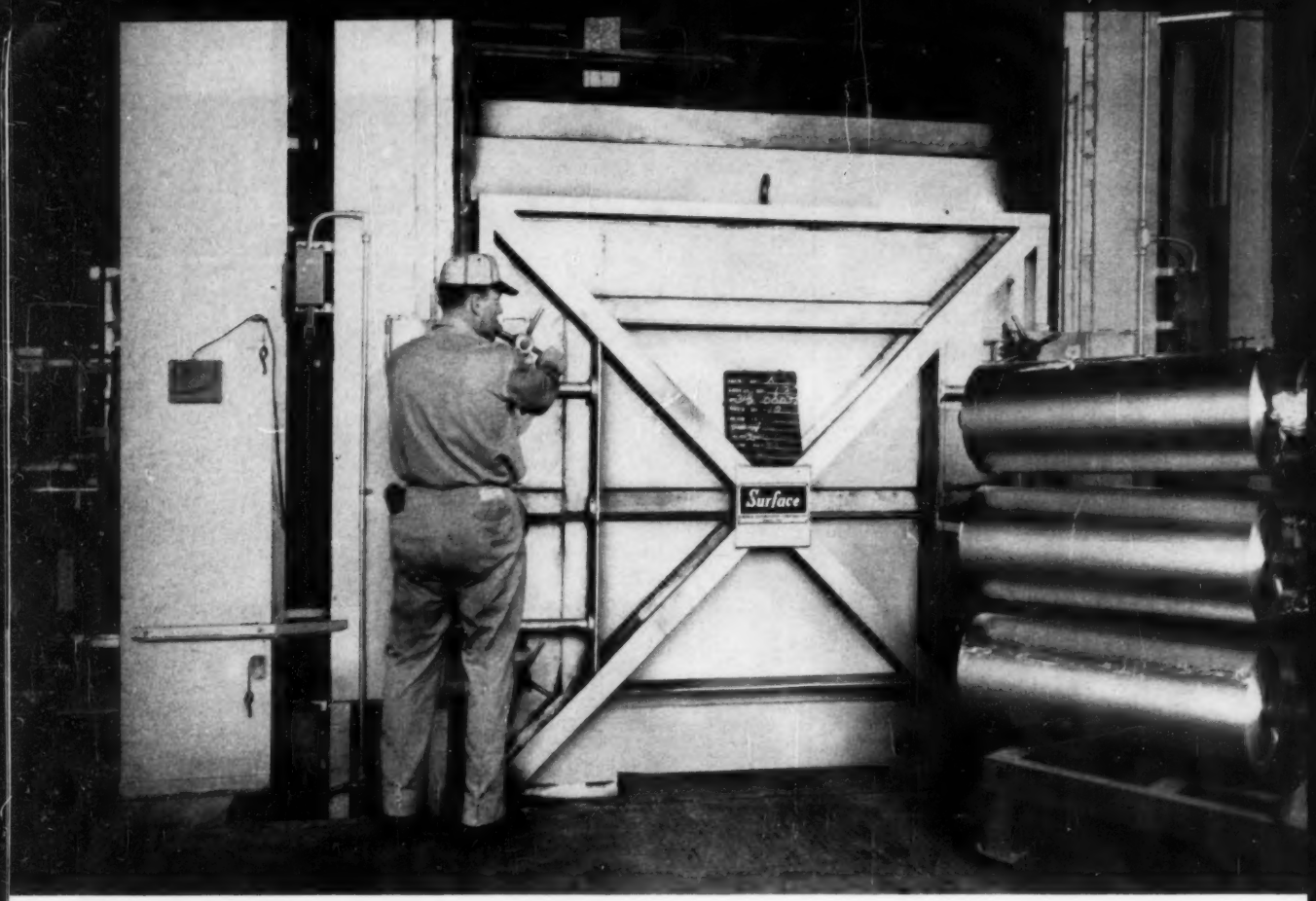
44 YEARS OF ENGINEERING LEADERSHIP

Circle 489 on Page 48-B



ANACONDA ALUMINUM ANNEALS FOIL WITH LOW-COST UNIFORMITY

in Surface Power Convection Furnaces

Phenomenal temperature uniformity (never varying more than 5°) and low costs are the profits earned by Anaconda Aluminum with four of these Surface Power Convection furnaces in their Louisville plant.

Each furnace anneals an 8,000-lb. load of coiled aluminum foil in a seven-hour heating cycle. Coils are stacked on racks, as you see here, and fork-lifted directly into the furnaces. Surface DX® generator gas protects the foil during the cycle.

Power Convection* equipment simplifies furnace construction,—just one fan, minimum furnace size for its capacity. This reduces both first cost and operating maintenance. For more data on Surface Power Convection equipment write for Bulletin SC-182. Surface Combustion, 2377 Dorr Street, Toledo 1, Ohio. In Canada: Surface Industrial Furnaces Ltd., Toronto, Ontario.

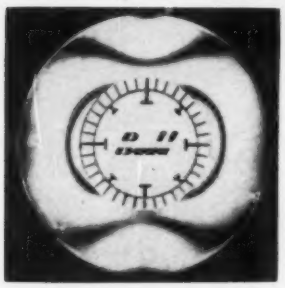
*Trademark of Surface Combustion, Division of Midland-Ross Corp.

Surface

A division of Midland-Ross Corporation MR

Circle 490 on Page 48-B

Rosette Gages for Stress Analysis



The "PhotoStress" rosette gage is the only gage which directly indicates orientation and magnitude of principal strains. No instruments or electrical connections are required, thus simplifying stress analysis problems. The gage – applied easily and rapidly to metal, concrete, wood, and other materials – has a wide range of uses, such as testing large bridges and structures, railway and automotive frames, ocean-going ships, aircraft, and large missiles. *Budd Instruments Div.*

For further information circle No. 220 on card

Production and Casting Equipment

Vacuum Metallizers

Electron bombardment heating sources have been adapted to standard vacuum coaters for depositing high-temperature metals – such as tantalum, tungsten, and zirconium – and for research into the evaporation of ultra-pure alloy systems. A popular combination is the "Model 3144" coater and an electron-beam gun or annular ring, with ratings up to 6 kw. Top operating temperature is practically unlimited, since the bulk material (being evaporated) serves as its own container. The coater is equipped with a high-speed, fractionating diffusion pump (6 in.), and mechanical pumps (15 to 30 cfm.) for roughing and back-up. *NRC Equipment Corp.*

For further information circle No. 221 on literature request card, p. 48B

Dewpoint Measuring Instrument

Dewpoints as low as −150° C. (−300° F.) can be measured in seconds with an instrument made by *Atkins Technical Instruments.* The unit, which gives accurate readings regardless of flow rate, is suited to continuous read-out or random sampling of atmospheres associated with melting and heating processes, chemical manufacture, and semiconductor production. Sensitivity is one part in 10 million. The sensor is unaffected by most atmospheric conditions and can take measurements under pressures up to 2000 psi.

For further information circle No. 222 on card

Maintaining Blast Furnace Linings

Relining a blast furnace with brick may take up to two months; a gunned, monolithic installation takes ten days. In addition to getting the furnace in production sooner, a gunned repair job saves the good brickwork still in the structure. *Harbison-Walker* offers a complete line of gun-clay products and installation techniques for maintaining blast furnace linings. If lining repair jobs are done correctly furnace life is extended two or three years, substantially reducing refractory costs per ton of iron produced.

For further information circle No. 223 on literature request card, p. 48B

Parts and Forms for Design and Applications

Flattener for Stamped Parts

This automatic machine flattens and straightens parts rapidly, eliminating hand-straightening operations. Finish dimensions are within 0.003 in. of true flatness. The machine utilizes a series of small-diameter work rolls supported by multiple back-up bearings. A wide variety of flat, stamped parts can be handled by the machine, employing either hand or automatic feeding. *Voss Engineering Co.*

For further information circle No. 224 on literature request card, p. 48B

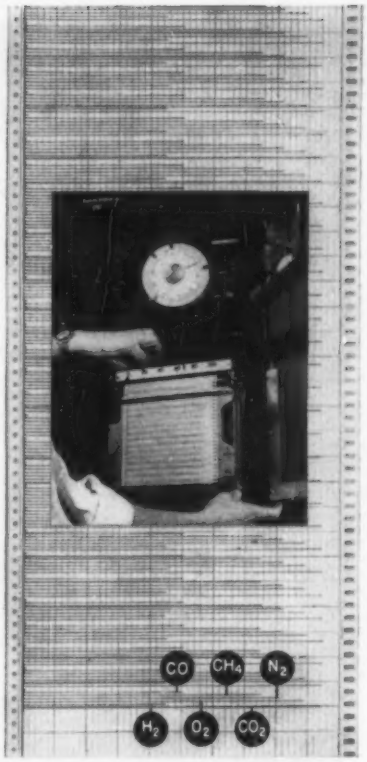


Chart record shows 6 components of furnace atmosphere measured cyclically by Furnace Gas Analyzer (inset).

NOW a Furnace Gas Analysis COMPLETE, ACCURATE, AUTOMATIC

The new Perkin-Elmer Furnace Atmosphere Analyzer lets you analyze furnace atmospheres with all the accuracy, speed and completeness needed for precise control of heat-treat furnaces, gas generators, kilns or other combustion devices.

This instrument automatically records volume percent of each of the usual four gases – O_2, CO, CO_2, CH_4 – or other combinations of four components. And special designs handle five to eight components.

Complete details on this rugged plant-tested instrument are given in a new booklet. Write for free copy today.

INSTRUMENT DIVISION
Perkin-Elmer
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NORWALK, CONNECTICUT
Circle 491 on Page 48-B

SYLVANIA FIRES POINT-BLANK

...at transforming research for the military into tools for industry

At 4600°F. gold turns to liquid. Chromium boils. Silver vaporizes. But molybdenum stays solid.

At Sylvania, such high temperatures help our scientists turn defense research on tungsten and molybdenum into practical answers for industry.

For instance, not long ago we devised a new method in which refractory metals are produced as powder of controlled particle size. This powder is isostatically pressed at high pressure and then sintered at high temperatures. Result? Ingots, bars—even intricate shapes—can be produced more efficiently, with more uniform compaction.

Why not take a good look at refractory metals to answer your needs. The identical properties that solve the problems of throat inserts for rockets and missiles can pay *you* dividends in die-casting dies and cores, hot-work tools, molds, and in many other ways.

Want the full story? Or experienced technical help in proving out your special ideas? Write Chemical & Metallurgical Division, Sylvania Electric Products Inc., Towanda, Pennsylvania.

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Subsidiary of **GENERAL TELEPHONE & ELECTRONICS**

Circle 492 on Page 48-B

NEW TOOL STEEL SERVICE

cuts
inventory
costs

Using too many grades of tool steel can lead to over-stocking—

that's when you need the benefits of Crucible's new Tool Steel Service!

A Crucible Service Engineer can prove that buying a few basic grades—

in quantity—enables you to carry fewer pounds in stock...

gives you a lower price per pound (you eliminate small quantity "extras"),

and with fewer grades to identify, you reduce the possibility of "mixed" steel.

All through standardizing on a few basic steels!

For the full story on this cost-reducing service, call in a Crucible Service Engineer

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CRUCIBLE STEEL OF CANADA, LTD., SOREL, QUEBEC, CANADA

Circle 493 on Page 48-B

Have a Metal Cleaning Problem

Detrex Engineers Have Been Coming Up With "Cost Saving" Answers for 30 Years

Every metal cleaning operation has its own particular problems—but they're seldom new to the Detrex engineer. With 30 years of experience, he can produce the right formula to insure maximum productivity and economy in your operation.

He will analyze your product, the type of soil to be removed, the proper equipment and cleaning agent needed, the space and manpower required—every factor that bears on the problem.

When he gives you his recommendation, you can depend upon it to make sense—and save dollars. And when you put his recommendation into practice, you can depend upon Detrex to follow through with the finest service in the business.

Depend on DETREX for Every Metal Cleaning and Processing Need

- PERM-A-CLOR NA (Trichlorethylene)
- Solvent Degreasers
- Ultrasonic Equipment
- Industrial Washer
- Phosphate Coating Compounds
- PAINTBOND Compounds
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- Alkali and Emulsion Cleaners
- Rustproofing Materials
- Extrusion and Drawing Compounds
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Write for your free copy of Dr. C. E. Kircher's informative paper: "Solvent Degreasing—What Every User Should Know."

DETREX CHEMICAL INDUSTRIES, INC.

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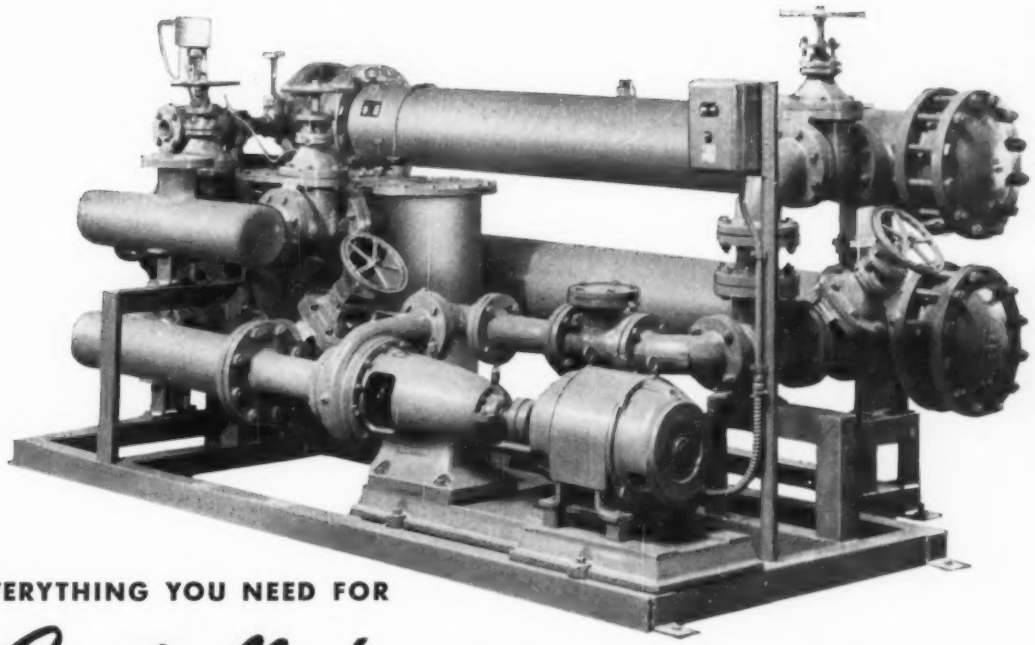
World's Largest Exclusive Producer of Cleaning Chemicals and Equipment

Circle 494 on Page 48-B



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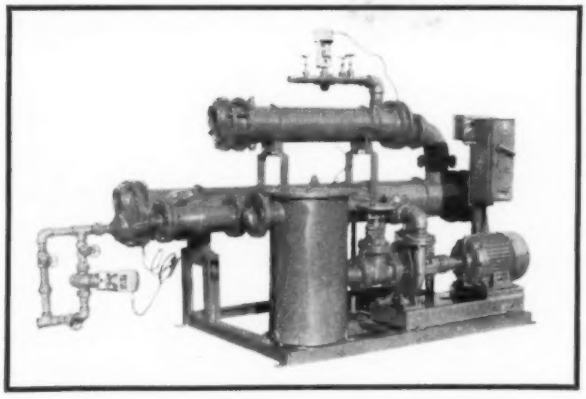
Controlled QUENCH OIL COOLING

...EITHER COMPONENT PARTS OR SELF-CONTAINED UNITS



BOTH HEATS AND COOLS QUENCH OIL

This typical B&G self-contained unit, as installed in automotive plant, both heats and cools quench oil to definite temperature specifications.

A B&G Self-Contained Oil Quenching System, factory-engineered and factory-assembled, avoids assembly errors, saves labor costs and can easily be moved if plant layout so demands. Your only responsibility, once the unit is delivered, is to place it in position and connect it to the quench tank and water lines. Or, if preferred, component parts can be furnished for assembly on the job.

This system circulates oil from the quench tank, cools and strains it, and pumps it back at a rate which keeps oil at the right temperature throughout the quench period. Every batch is quenched under identical conditions, hence every batch emerges identical in quality.

With a B&G Oil Quenching System, quenching is automatically controlled and results are predictable. You cut losses resulting from excessive rejects and realize a substantial "inside profit."

B&G Quench Tanks

Properly designed to induce maximum turbulence in the quench oil, B&G Quench Tanks are available in standard models or can be built to meet any specific quenching requirement.

Send for this combined Catalog and Simplified Selection Manual for B&G Self-Contained Quench Oil Coolers.

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BELL & GOSSETT COMPANY

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Canadian Licensee: S. A. Armstrong Ltd., 1400 O'Connor Drive, Toronto 16, Ont.

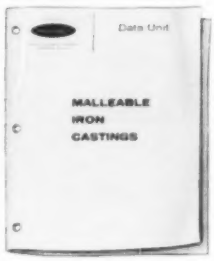
Circle 495 on Page 48-B

New Cars and Trucks Use More Malleable For Better Performance...Lower Cost

As the automotive industry steps up its drive to pack greater performance into lighter weight vehicles and still hold costs in line, the demand for Malleable iron castings continues to increase. Noted for their strength, toughness, machinability and economy, Malleables are used as key components in every make and type of vehicle.

Matching each new advance in automotive technology, Malleable is now available in a broad range of properties, including tensile strengths from 50,000 to 120,000 psi!

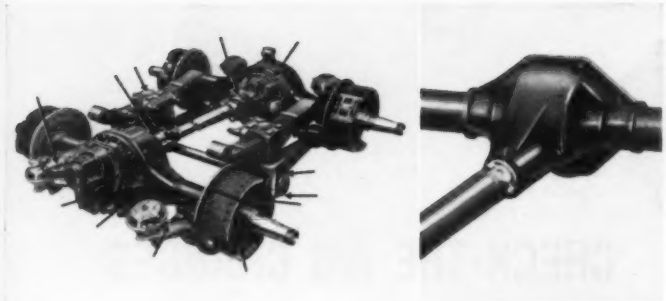
Find out now how much Malleable castings can improve your products. Contact any company that displays this symbol —



For Free Literature on advantages of Malleable iron castings, with examples from the automotive industry, ask any member company for Data Unit No. 113, or write to Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.

MEMBER
MALLEABLE
CASTINGS COUNCIL

Testifying to Malleable's outstanding ability, pearlitic Malleable iron crankshafts are now used in both cars and trucks, like this new heavy-duty highway hauler. Pearlitic Malleable was chosen for its high strength, wear resistance, damping capacity and machinability . . . Malleable is the most machinable of all ferrous metals of similar properties.

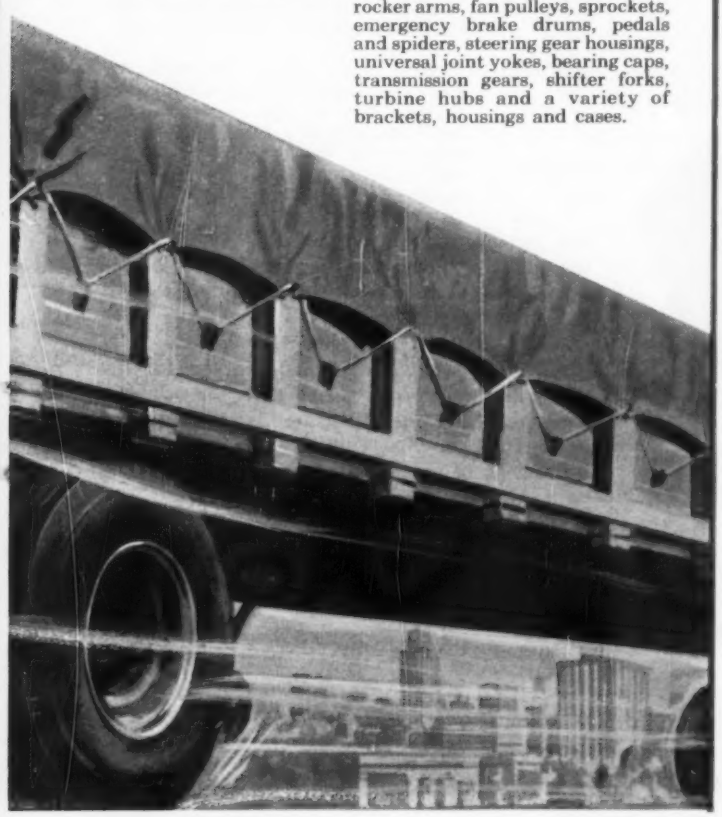


From the smallest cars to the largest trucks, all American vehicles rely on Malleable for a range of uses. In this tandem axle, for example, a total of 36 parts is Malleable.

Malleable differential carriers form the backbone of the rear axles on many new compact cars, as shown at the right above. Tubular steel extensions are pressed into the Malleable housing where they are "puddle" welded. Decisive factors in Malleable's selection were strength, economy, ease of machining and ability to be produced in a design that required a minimum of tooling expense.

The increasing conversion from other materials to Malleable castings for all kinds of parts from crankshafts to door hinges is adding momentum to the automotive industry's steadily increasing use of Malleable.

Among the many Malleable iron castings in this composite car are torsion bar arms and brackets, rocker arms, fan pulleys, sprockets, emergency brake drums, pedals and spiders, steering gear housings, universal joint yokes, bearing caps, transmission gears, shifter forks, turbine hubs and a variety of brackets, housings and cases.



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Albion Malleable Iron Company, Muncie Division, Muncie
Link-Belt Company, Indianapolis 6
National Mall. & Steel Castings Co., Indianapolis 22

IOWA
Iowa Malleable Iron Co., Fairfield

MASSACHUSETTS
Belcher Malleable Iron Co., Easton

MICHIGAN
Albion Malleable Iron Co., Albion
Auto Specialties Mfg. Co., Saint Joseph
Cadillac Malleable Iron Co., Cadillac
Central Fdry. Div., Gen. Motors, Saginaw

MINNESOTA
Northern Malleable Iron Co., St. Paul 6

MISSISSIPPI
Mississippi Malleable Iron Co., Meridian

NEW HAMPSHIRE
Laconia Malleable Iron Co., Laconia

NEW YORK
Acme Steel & Mall. Iron Works, Buffalo 7
Frazer & Jones Company Division Eastern Malleable Iron Co., Solvay
Oriskany Malleable Iron Co., Inc., Oriskany
Westmoreland Mall. Iron Co., Westmoreland

OHIO
American Malleable Castings Co., Marion
Central Fdry. Div., Gen. Motors, Defiance
Dayton Mall. Iron Co., Ironton Div., Ironton
Dayton Mall. Iron Co., Ohio Mall. Div., Columbus 16
National Mall. and Steel Castings Co., Cleveland 6

PENNSYLVANIA
Buck Iron Company, Inc., Philadelphia 22
Erie Malleable Iron Co., Erie
Lancaster Malleable Castings Co., Lancaster
Lehigh Foundries Company, Easton
Meadville Malleable Iron Co., Meadville
Pennsylvania Malleable Iron Corp., Lancaster

TEXAS
Texas Foundries, Inc., Lufkin

WEST VIRGINIA
West Virginia Mall. Iron Co., Point Pleasant

WISCONSIN
Belle City Malleable Iron Co., Racine
Chain Belt Company, Milwaukee 1
Federal Malleable Company, Inc., West Allis 14
Kirsh Foundry Inc., Beaver Dam
Lakeside Malleable Castings Co., Racine
Milwaukee Malleable & Grey Iron Works, Milwaukee 46

These companies are members of the Malleable Castings Council

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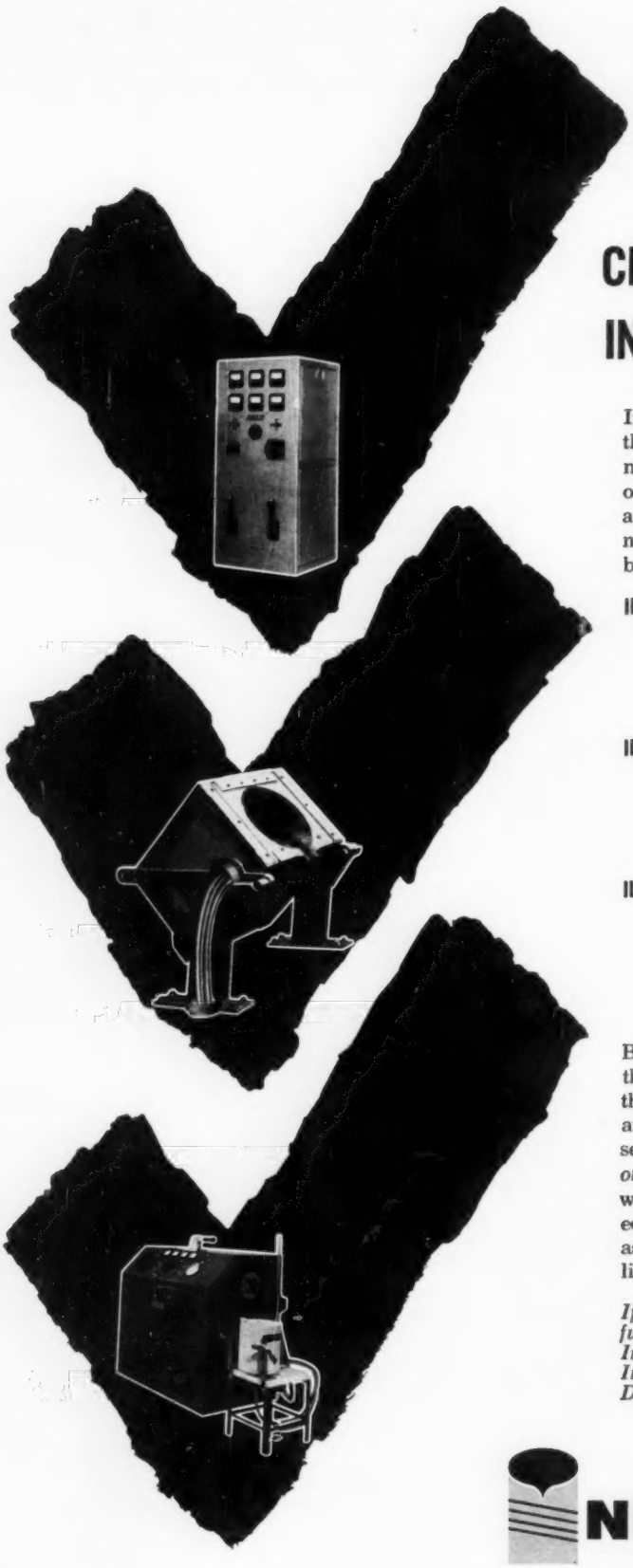


CHECK THE BIG CHANGES IN INDUCTION MELTING

In just seven years, Inductotherm has changed the face of induction melting with a barrage of new ideas. Some have resulted in lower costs . . . others have simplified operation, maintenance, and installation. But all have been aimed at making induction melting more useful, and a better buy, than ever before.

IDEA #1 . . . *Packaged Controls:* By shrinking the size of capacitor banks to permit behind-the-panel mounting, Inductotherm was able to introduce the first pretested, prewired melting furnace controls in induction history.

IDEA #2 . . . *Integral Power:* M-G set, starter, transformer and capacitors were first packaged as a compact movable unit in the melting control console of the Inducto "Integral" series, which now includes capacities up to 100 KW.

IDEA #3 . . . *Design Innovations:* Inductotherm has consistently been first with new features in furnace design. Tilting furnace power feed through the trunions is one example, Heliarc welded furnace construction is another.

But these ideas barely scratch the surface. For the greatest innovation has been the Inductotherm concept of service. Not just fast repairs and overnight replacement of parts (even M-G sets) . . . but a basic concept: *Inductotherm is out to fit induction melting to your needs.* We will make every possible effort to improve our equipment and the induction technique, never asking you to trim your requirements to the limitations of our equipment.

If you'd like more information on Inductotherm furnaces, write for Bulletin 70. But, for a taste of Inductotherm service, ask to have an engineer call. Inductotherm Corporation, 412 Illinois Avenue, Delanco, New Jersey.

INDUCTOTHERM

Circle 497 on Page 48-B

NEW LITERATURE • NEW LITERATURE • NEW LITERATURE •

There are cheaper ways to heat treat metals . . .

BUT NOT WHERE YOU NEED *Precision* RESULTS

ON A MASS PRODUCTION BASIS!

When heat treating requirements are not in the least critical, there are probably cheaper ways you can handle them than in salt. But when highly precise results must be obtained—economically, with a minimum of labor cost—then salt baths offer possibilities that cannot be overlooked.

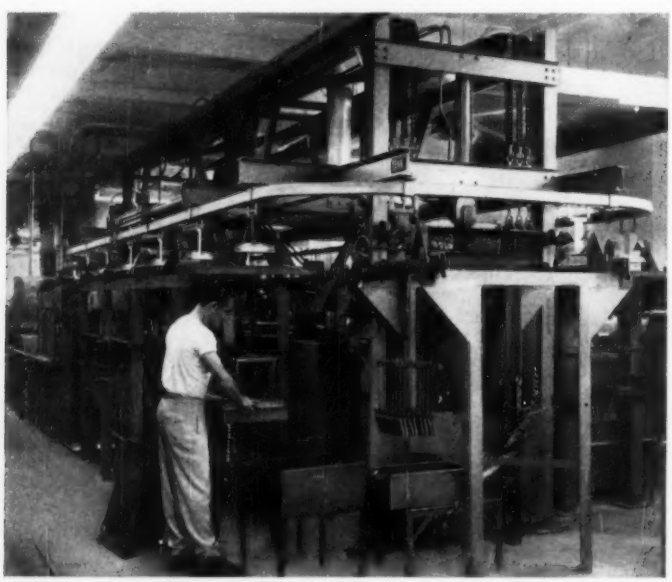
It is now common practice to handle on a salt bath mass-production basis, heat treating so ultra-precise that it may have been regarded as a laboratory method not many years ago.

Moreover, extending far beyond their obvious advantages in hardening steels, salt baths have "come of age" in many different directions.

These range from isothermal processing to heating for forging; from aluminizing to various types of brazing including aluminum and magnesium brazing; from simultaneous carburizing and brazing to heat transfer applications and others which cannot yet be discussed.

Metal fabricators long ago learned to come to Ajax, not merely to buy furnaces, but to enlist specialized heat treating and metallurgical help in solving specific problems; or in improving, economizing or modernizing specific heat treating processes. This has brought Ajax in close association with heat treating requirements, trends, procedures and possibilities over a broad front.

In numerous instances, it has made the ultimate purchase of Ajax equipment incidental to establishing new and better ways of doing things; or of handling critical heat treating jobs to new, higher standards of precision, quality, and economy.



MECHANIZED AUSTEMPERING—Typical of the trend toward salt bath mechanization, this Ajax installation in the Hartford, Conn. plants of the Royal McBee Corporation austempers type bars. It has materially increased production, saved time and improved quality of the parts.

AJAX

HULTGREN

SALT BATH FURNACES

Internally heated electric and gas-fired types

The most efficient heat treating principle for a wide variety of work . . . Pioneered by Ajax in the largest line of furnace types, shapes and sizes for modern production needs.

AJAX ELECTRIC COMPANY

910 Frankford Ave.,
Philadelphia 23, Pa.

LEADERS IN SALT BATH PROGRESS SINCE 1936

Circle 498 on Page 48-B

sion-resistant alloys, their properties, forms, and the corrosives they will resist.

255. Tungsten and Molybdenum

Produced from pure metal powders prepared by hydrogen reduction, cold pressed and sintered in a hydrogen furnace. More information on product and applications is available from *General Electric Co.*

256. Superalloy Forgings

Wyman-Gordon will supply information on forgings made of Waspaloy, René 41, Astroloy, Udimet 500, M-252, and titanium alloys.

257. Refractories

Carborundum has published "Super-Refractories" booklet, full of useful data on unusual refractories, including silicon carbide with high heat conductivity for furnace muffles.

258. Beryllium Oxide

BeO is an excellent reflector and moderator of neutrons, is inert to chemical attack, and has good thermal conductivity. Melting point is 4658°F. *Brush Beryllium* has detailed information on "Uox" sintered BeO components.

259. Cobalt-Base Alloys

Haynes Stellite Co. has data on cobalt-base alloys for tough applications. Available as castings, forgings, sheet and bar stock, or fabricated parts.

260. Ta, W, Mo, Cb

Fansteel Metallurgical Corp. has a "Warehouse Price and Stock List" on refractory metals and alloys—Cb, Ta, W, Mo, and others.

261. Tungsten Ingots

Pamphlet discusses advantages and properties of products made from tungsten and molybdenum ingots. *Sylvania Electric Products Inc.*

262. Alloy for 2300°F. Service

Information from *Electro-Alloys Div.* on composition and properties of "Supertherm," a superior alloy for static, centrifugal, and shell-molded castings operating in the 1800-2300°F. range.

263. Graphite Products

Check the economic advantages of using carbon and graphite products—for operations requiring refractories to handle molten irons inside and outside the cupola. *National Carbon Co.*

264. Heat Resistant Castings

Booklet "Heat and Corrosion Resistant Castings . . . Their Engineering Properties and Applications." *International Nickel Co.*

265. Thermal Fatigue

The *Electro-Alloys Div.* has published "The Mechanism of Thermal Fatigue" by H. S. Avery.

266. Alumina Tubes

Morganite, Inc. will send details on 99.7% pure, smooth, impervious, recrystallized alumina tubes for temperatures to 3540°F.

267. Rene 41

G.E.'s Metallurgical Products Dept. has data on René 41; unique properties make it ideal for use in everything from jets to machine components.

268. High-Temperature Alloys

Seventeen "Haynes" alloys are compared against each other in the areas of physical, mechanical and chemical properties and stress-rupture data. 20-p. booklet from *Haynes Stellite Co.*

269. Ceramic-to-Metal Seals

Flyer from *Wilbur B. Driver Co.* gives data on "Ceramiseal," an iron-nickel-cobalt alloy for ceramic-to-metal sealing applications.

Tool Materials

270. Toolsteels

The *Ziv Steel & Wire Co.* will send literature discussing their toolsteels—bar stock, forgings and castings.

271. Colloidal Graphite

The *Grafo Colloids Corp.* has prepared a booklet, "The Biggest Ounce of Protection," covering colloidal graphite applications in the aluminum extrusion industry.

272. Rotary Slitters

Illustrated brochure on slitting operations and equipment describes methods, time studies, operating cycles, materials handling, and gives full specifications. *Yoder Co.*

273. Metal Spinning

Monthly bulletin covers case histories on a variety of metal-spinning jobs in the military and industrial field. *Spincraft, Inc.*

274. Tool and Die Steels

Data sheets on "Thermotem" and "Thermoneal" tool and die steels. Instructions for forging, annealing, hardening, and tempering plus hardness data and elevated temperature properties. *Heppenstall Co.*

275. Colloidal Dispersions

Bulletin No. 426 discusses effective lubrication under adverse conditions of extreme temperature, pressure or abrasion. *Acheson Colloids Co.*

276. Spherical Powders

8-p. data sheet contains information on spherical powders—copper, aluminum, nickel, 316 stainless, tungsten and Nichrome V—ranging in size from 5 to 150 microns. *Linde Co.*

277. Automatic Shearing

General Electric Co. will send flyer, GEA-6949, outlining their system for cropping mill slabs precisely—for increased production and reduced scrap losses.

278. Roll Catalog

Pamphlet No. 601 from *Barclay Machine, Inc.* gives the facts on complete line of rolls for any service application . . . any size or type, fabricated or cast, bare or covered.

279. Wire-Forming Machine

8-p. brochure from the *Baird Machine Co.* discusses the production capabilities of automatic high-speed ribbon and wire forming machines.

280. Graphite Lubricants

Data sheets from *Dixon Crucible Co.* present applications for colloidal graphite suspensions, including die casting and extrusion operations.

281. Iron Powders

Performance graphs and processing data on iron powders have been compiled into Bulletin No. 2, issued by *Alan Wood Steel Co.*

Industrial Heating Equipment

282. Sintered Products

16-p. Bulletin No. 603 gives the advantages, physical properties and applications of powdered metal products and discusses the design principles and the different types of furnaces used in sintering operations. *Electric Furnace Co.*

283. Box Furnaces

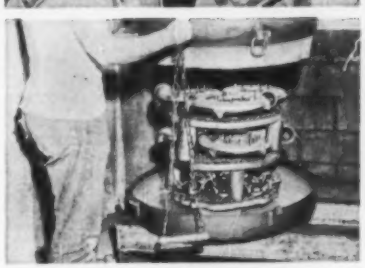
Flyer from *Lucifer Furnaces, Inc.* gives

Circle appropriate number on Reply Card, p. 48B

Stainless Brazing Program Reduces B-58 Aircraft cost

Complex Turbine Assembly Brazed in One Operation

Accurately controlled assembly by brazing is the method used to speed production of compressor turbines for the B-58 aircraft. Turbines are of stainless steel, are used in aircraft's air conditioning system. More than 60 separate pieces forming turbine are simultaneously brazed with dimensional tolerance held within .002 in. Brazing is done with Nicrobraz (Standard) filler metal under pure dry hydrogen atmosphere at 2150° F. Cooling rate is controlled. Work is done on mass production basis by Stainless Processing Division.



Nicrobraz® Processing Benefits:

- Brazed joints as strong as parent metal
- More than 60 parts joined in one brazing operation
- Distortion held to within ±0.002"
- No finish machining was needed
- Brazed assembly was fully annealed
- No clean-up, assembly was bright and clean

Our stainless brazing facilities can help you solve production problems. Call or write for full information.

WALL COLMONOY CORPORATION

Stainless Processing Division

19345 JOHN R STREET • DETROIT 3, MICHIGAN

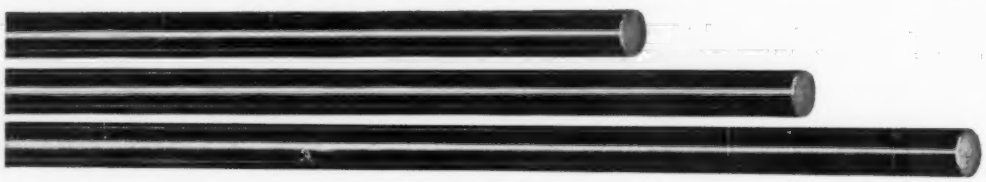
Representatives in all key industrial areas

PROCESSING PLANTS: Detroit, Michigan • Morrisville, Pennsylvania • Dayton, Ohio • Montebello, California

Circle 499 on Page 48-B

*Important Cost-Reducing News from 30 Years of Research and Production of High-Strength, Furnace-Treated Steels!**

NOW IN ALLOY AS WELL AS IN CARBON



BLISS & LAUGHLIN MONEY-SAVING Strain-Tempered®

COLD FINISHED STEEL BARS

* Eliminate Heat-Treating Costs
* Save In Grade and Processing Extras
* Pay Only For the Grade Needed

Bliss & Laughlin again brings you another benefit of its long-range product development program—ALLOY Strain-Tempered bars to supplement an extensive line of CARBON Strain-Tempered bars. The cost-saving advantages are significant!

IF YOU USE HEAT-TREATED ALLOY BARS, you can save up to 30% in processing extras by switching to Bliss & Laughlin Strain-Tempered Alloy bars. Strength and hardness are equal. Machinability is comparable. Ductility is somewhat lower, but adequate for many applications. Size limitations depend on individual specifications. With Strain-Tempered Alloy bars, it is frequently possible to select a grade with a lower grade extra than is possible with heat-treated alloys, thus saving additional money.

IF YOU HEAT TREAT ALLOY STEEL PARTS, Strain-Tempered Alloy bars may meet your hardness specifications at lower cost. In addition, problems of distortion and finish associated with heat treatment are eliminated. Strain-Tempered Alloys can be tailored to hardness in the 30 Rockwell "C" range and up to 40 Rockwell "C" and higher in some combinations of size and alloy grade. Ductility and impact properties, while lower than in heat-treated alloys, do not impair performance in many applications.

IF YOU HEAT TREAT CARBON STEEL PARTS, Bliss & Laughlin Strain-Tempered Carbon steel bars will provide equivalent strength and hardness, with adequate ductility and toughness. You save heat-treating costs, reduce fabricating time and eliminate costly operations formerly required to correct distortion of parts in heat treatment.

IF YOU NOW BUY C-1144 STRAIN-TEMPERED OR COMPARABLE TRADE NAME STEELS, a review of your machining operations may indicate costs can be reduced by switching to a lower-cost, less-machinable grade. We'll gladly send a chart showing comparative data. By selecting the grade providing only the machinability needed, you do not pay a premium for machinability you do not use. Savings can range up to $24.00 per ton.

RESEARCHED AND PRODUCED FOR 30 YEARS. High-strength, furnace-treated steel bars were pioneered by Bliss & Laughlin 30 years ago. They are backed by nearly 70 years of experience in producing all grades of cold finished steel bars that can be used profitably by customers. In 1929, the first Strain-Tempered bar was produced for automobile drive shafts. By 1931, Bliss & Laughlin supplied 75% of one automotive company's requirements. Today Bliss & Laughlin is furnishing large quantities of standard alloy grade Strain-Tempered bars for drive shafts, as well as for many other purposes requiring high strength. A notorized certified report on the chemical and physical properties accompanies every Strain-Tempered mill shipment, evidence of the exacting quality standards which you can expect from Bliss & Laughlin.

You will be money ahead asking a Bliss & Laughlin representative to analyze your present use of high-strength alloy and carbon steels. He will recommend without obligation, the most suitable, least costly alloy or carbon grade from Bliss & Laughlin's extensive line of Strain-Tempered bars.

Specialists in Finish, Accuracy, Straightness, Strength and Machinability

BLISS & LAUGHLIN

GENERAL OFFICES: Harvey, Ill. • MILLS: Harvey, Detroit, Buffalo, Los Angeles, Seattle, Mansfield, Mass.

Leading Independent Producer of Cold Finished Steel Bars

data on general purpose, box-type furnaces for hardening, annealing, drawing and preheating. Temperatures to 2300°F.

284. Coaxial Extension Cable

The *L. C. Miller Co.* will send a flyer discussing their coaxial extension cable, which takes the work coil to the work in high-frequency induction heating applications.

285. Hump Furnace

Flyer from *General Electric* offers data on mesh-belt hump furnaces for continous bright brazing, heat treating, or sintering of stainless steel up to 2200°F. GED-3990.

286. Pneumatic Temperature Control

Leaflet 151-1 from *Burling Instrument Co.* discusses "Model HA" differential expansion-type pneumatic temperature control. Standard ranges, tube sizes and performance data.

287. Industrial Furnaces

Bulletin SC-175 describes line of industrial furnaces—including pit, pot, box, link, muffle, tube, snap or laboratory furnaces. *Surface Combustion Div.*

288. Gas-Air Dryer

C. I. Hayes, Inc. will send a flyer describing their recirculating "Molecu-Dryer Type MS-RD" dryer. Applications include air drying, gas drying and separating, and other uses calling for dewpoints of —100°F. or lower.

289. Heat-Processing Equipment

Bulletin SEC-11 covers line of standard pre-engineered industrial furnace equipment for heat processing. . . . includes special furnace selection guide. *Sunbeam Equipment Corp.*

290. Temperature Control

Bulletin 1960 describes an instrument which provides completely stepless regulation of temperature and is fully automatic. *Blue M Electric Co.*

291. Infra-Red Burner

4-p. leaflet on gas-fired infra-red burners include performance curves, and data on application, selection and specifications. *Byrant Industrial Products Corp.*

292. Bath Heater

Flyer from *Electrical Accessories Co.* gives information on new heater for corrosive liquids—both acid and alkaline.

293. Thermal Systems

12-p. specification sheet covers bulbs, tubing, and fittings for gas, mercury, and vapor-actuated thermal systems, and includes detailed information on sizes, lengths and materials. *Minneapolis-Honeywell.*

294. Continuous Brazing Furnace

Bulletin HMB-60 discusses the hump-type mesh-belt furnace which provides low dewpoint atmospheres for continuous brazing, annealing, hardening, and sintering operations. *Harper Electric Furnace Corp.*

295. Thermocouple Alloys

Hoskins Mfg. Co. will send data on Chromel-Alumel thermocouple alloy and special close-tolerance wires for precision research work.

296. Radiant Tubes

General Alloys Co. has published literature on wrought-cast radiant tubes which give consistent, long life.

297. Metal Process Belts

High-temperature catalog from *Ashworth Bros. Inc.* describes metal process belts for operation at temperatures up to 2100°F.

298. Sheathed Thermocouples

Bulletin 1200-4 from *Claud S. Gordon Co.* on "Serv-rite" sheathed thermocouples ranging in size from 0.020 to 0.500 in. O.D.

299. Gas Furnaces

The *American Gas Furnace Co.* will send literature on their equipment, including a rotary retort and reciprocating hearth furnace.

300. Low-Temperature Cabinets

Folder from *Revco Inc.* describes ultra low-temperature cabinets for producing temperatures down to —140°F.

301. Induction Hardening

The Ohio Crankshaft Co. has published a pamphlet, "Typical Results of Tocco Induction Hardening and Heat Treating."

302. Gas Alloying

The *Lee Wilson Engineering Co.* will supply complete data on the "open coil" process of gas alloying.

303. Heating Elements

The Carborundum Co. will send information on the advantages of heating with "Globar" silicon carbide heating elements—for precise, economical electric heating.

304. Heat Treating Salts

The *American Cyanamid Co.* has prepared a brochure on their heat treating salts, and carburizing and case hardening compounds.

305. Production Chilling

Cincinnati Sub-Zero Products will send literature on sub-zero chambers, which offer uniform temperature control.

306. Heat Treating Ovens

Bulletin 157 on heat treating ovens designed for individual product and process requirements. *Young Brothers Co.*

307. Heat Exchangers

Bulletin from *Niagara Blower Co.* explains their "Aero" heat exchanger which transfers heat to atmospheric air by evaporative cooling.

308. Selector Switches

Thermo Electric Co., Inc. will send 4-p. flyer describing compact multi-point thermocouple selector switches for many temperature-checking applications.

309. Protection Tubes

Information from *McDanel Refractory Porcelain Co.* on ceramic protection tubes for temperatures to 3000°F.

310. Optical Pyrometer

"Micro-Optical" pyrometer measures targets as small as 0.001 in. . . . Temperature scales, 1300 to 5800°F. Catalog No. 95 from *Pyrometer Instrument Co.*

311. Industrial Gas Burners

Catalog from *Charles A. Hones, Inc.* covers a line of industrial gas burners and furnaces using low-pressure gas.

312. Production Carburizing

Bulletin P-59 from *Ipsen Industries, Inc.* describes pusher furnaces—which feature ceramic "Flame Busters"—for production carburizing.

313. Induction Heating Units

Catalog on heating nonconducting materials to high temperatures (3000 to 3500°F.) in vacuum or special atmosphere. *Lepel High Frequency Labs.*

314. Salt Bath Furnaces

For hardening high-alloy steels there is no match for salt baths, which provide speed, freedom from distortion, and uniformity. 70-p. catalog from *Ajax Electric.*

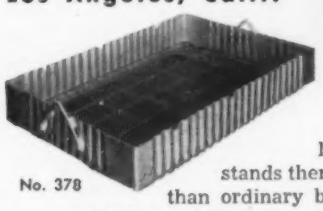
316. Metallurgy Courses

32-p. catalog describes courses available through Metals Engineering Institute. Individual home-study or in-plant "ex-

Circle appropriate number on Reply Card, p. 48B

STANWOOD'S Cor-Wal® BASKETS carry the load at

ABEGG-REINHOLD CO. Los Angeles, Calif.



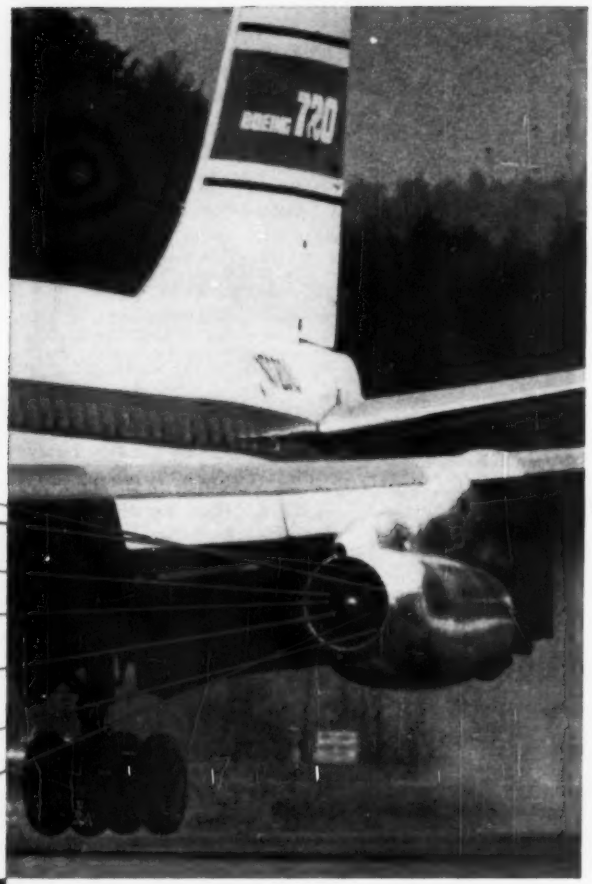
No. 378

The Cor-Wal design of baskets (and other heat treating containers too) increases service life by providing a unit that withstands thermal stresses for a much longer period than ordinary baskets. The design also provides for a lighter weight construction. A Cor-Wal basket is shown in the heat treating department of Abegg-Reinhold Co., makers of oil well drilling equipment—one of many manufacturers who are speeding operations and cutting costs with Cor-Wal baskets. Send for Catalog 60.

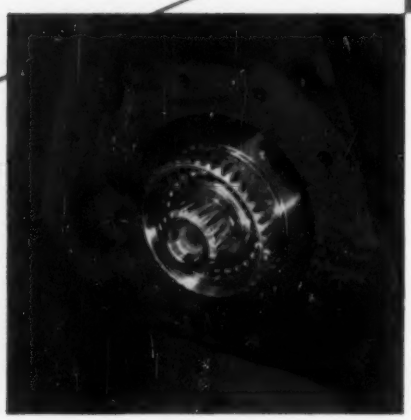
THE BIG NAME IN **STANWOOD** *HEAT TREATING CONTAINERS* **CORPORATION**

4817 W. Cortland Street — Chicago 39, Illinois

Circle 501 on Page 48-B



at the touchdown
LATROBE'S
VAC-ARC®
steel goes to work



Thrust reverser bearing assemblies, made of Latrobe's Vac-Arc BG 41 Stainless, take compressive stresses of more than 600,000 psi and temperatures in excess of 800°F. as new Boeing 720 jetliner brakes to a stop. Bearings by Torrington Co.; Thrust Reversers by Rohr Aircraft; Jet Engines by Pratt & Whitney Aircraft.

VAC-ARC BG 41 "hot hardness" withstands critical braking action of new Boeing 720

Through the use of thrust reversers and wheel brakes, the new Boeing 720 has been brought to a full stop within 2200 feet after runway touchdown—bringing high speed jet service to restricted runway facilities throughout the world.

The thrust reverser bearing assemblies, made of Latrobe's new Vac-Arc BG 41 Stainless (modified Type 440 C), withstand the critical stresses at elevated temperatures imposed by the braking action of reversing the jet engine thrust.

Here's another example of Latrobe Metalmasters meeting the challenge for super steels in the jet and missile age. Vac-Arc Steels (consumable electrode vacuum melted) continue to set new standards for cleanliness, homogeneity and high strength.

Do *you* have a high temperature-high strength specification problem? Call Latrobe!

Skillfully made in U. S. A. by

LATROBE Metalmasters

LATROBE STEEL COMPANY

LATROBE, PENNSYLVANIA

Branch Offices and Steel Service Centers:
BOSTON • BUFFALO • CHICAGO • CLEVELAND • DAYTON • DETROIT
HARTFORD • LOS ANGELES • MIAMI • MILWAUKEE • NEW YORK
PHILADELPHIA • PITTSBURGH • SAN LEANDRO • TOLEDO

Circle 502 on Page 48-E

tension" courses include elementary metallurgy, heat treating, welding and foundry operations. *American Society for Metals.*

317. Selective Hardening

Selas Corp. of America has published a pamphlet on selective hardening equipment. Hardening and tempering operations are combined in a continuous operation.

318. Furnace Tubes

The Pressed Steel Co. will send their catalog describing how all-sheet construction—in any size, shape or alloy—adds to furnace-tube life.

319. Vacuum Furnace

4-p. bulletin (GED-3793) discusses features and advantages of *General Electric's* refractory-free, radiation-shield vacuum furnace for critical heat treating to 4200°F.

320. Radiation Pyrometers

Bulletin TB1372 contains information on infrared radiation pyrometers, accurate within 1%; range is 120 to 2800°F. *Servo Corp. of America.*

321. Control for Temperature

Bulletin 109 gives description of equipment and operation of indicating, differential-expansion-type temperature control. *Burling Instrument Co.*

322. Resistor Box Furnace

The *General Electric Co.* has issued booklet GED-4305 on molybdenum-resistor box furnaces for annealing magnetic metals and bright brazing, annealing, sintering and forging of stainless steels and molybdenum—to 2300°F. or 3200°F.

Cleaning and Finishing Equipment

323. Hard Anodizing

4-p. leaflet sets forth details of the "Model 500 Allen-Dizor", an electrolytic process unit designed to prepare hard-anodized samples in the lab. *Allen Aircraft Products, Inc.*

324. Protective Coatings

Allied Research Products has published technical manual discussing "Iridite" chromate conversion coatings, and "Irilac" clear protective coatings for aluminum, magnesium and zinc-plated parts.

325. Barrel Finishing

Syntron Co. will send 4-p. brochure on vibratory barrel-finishing machines for deburring, deflashing, grinding, descaling, polishing and burnishing.

326. Electroplating Processes

24-p. Bulletin EP-102 discusses 18 electroplating processes, including three new nickel plating operations. *Hansen-Van Winkle-Munning Co.*

327. Tin Plate Testing

56-p. handbook sets forth details involved in chemical and physical testing of tin plate. *Tin Research Institute.*

328. Electroplating Equipment

146-p. illustrated booklet describes line of electroplating, polishing, and spray-painting equipment. *J. Holland and Sons.*

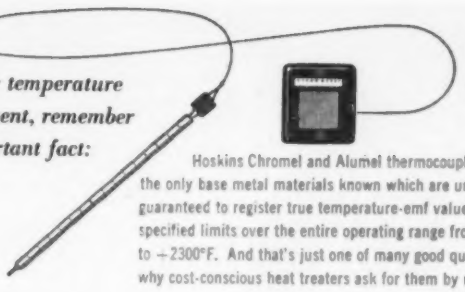
329. Silicon Rectifiers

20-p. booklet gives description of silicon rectifiers and states their advantages over other rectifying methods. *Westinghouse Electric Corp.*

330. "Heat-Proof" Coating

"C-R" coatings protect a wide range of metals against oxidation, corrosion, scaling, and gas absorption at temperatures as high as 2100°F. during heat processing operations. *Marshal Co.*

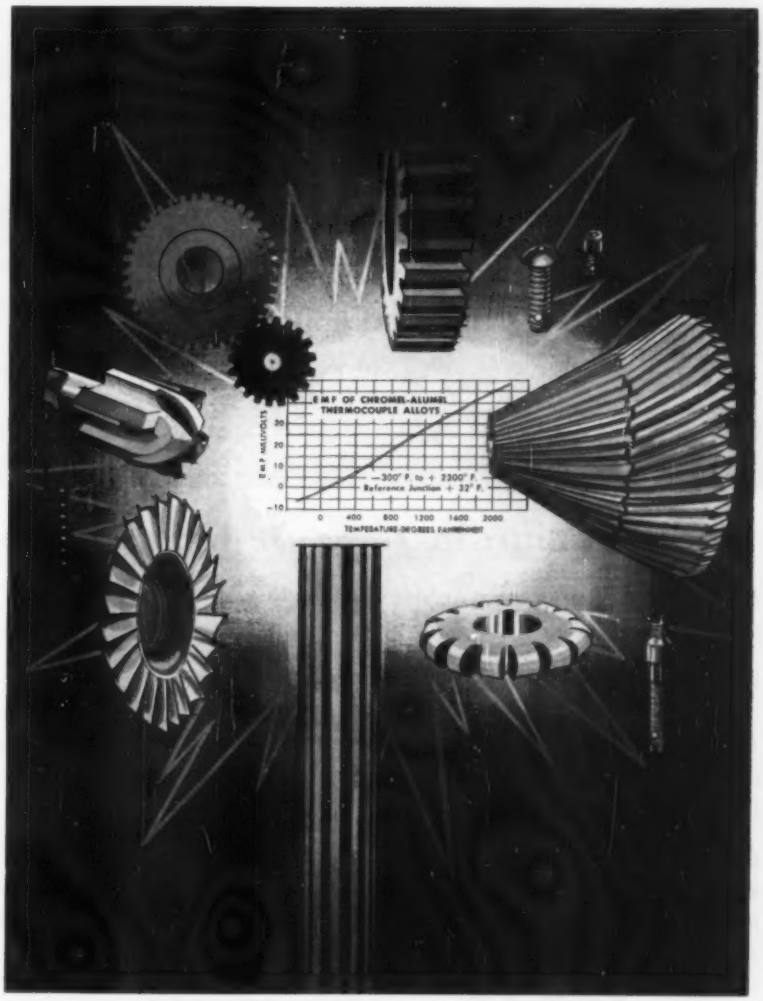
When you buy temperature control equipment, remember this very important fact:



Hoskins Chromel and Alumel thermocouple alloys are the only base metal materials known which are unconditionally guaranteed to register true temperature-emf values within close specified limits over the entire operating range from −300°F. to +2300°F. And that's just one of many good quality reasons why cost-conscious heat treaters ask for them by name . . .

Chromel®-Alumel®*

THERMOCOUPLE ALLOYS


EMF OF CHROMEL-ALUMEL THERMOCOUPLE ALLOYS
EMF MILLIVOLTS
−300° F. to + 2300° F.
Reference Junction + 32° F.
TEMPERATURE-DEGREES FAHRENHEIT

Available through instrument manufacturers, thermocouple fabricators, and pyrometer service companies. Write for complete technical data.

**Trade names you can trust for accurate temperature measurement!*

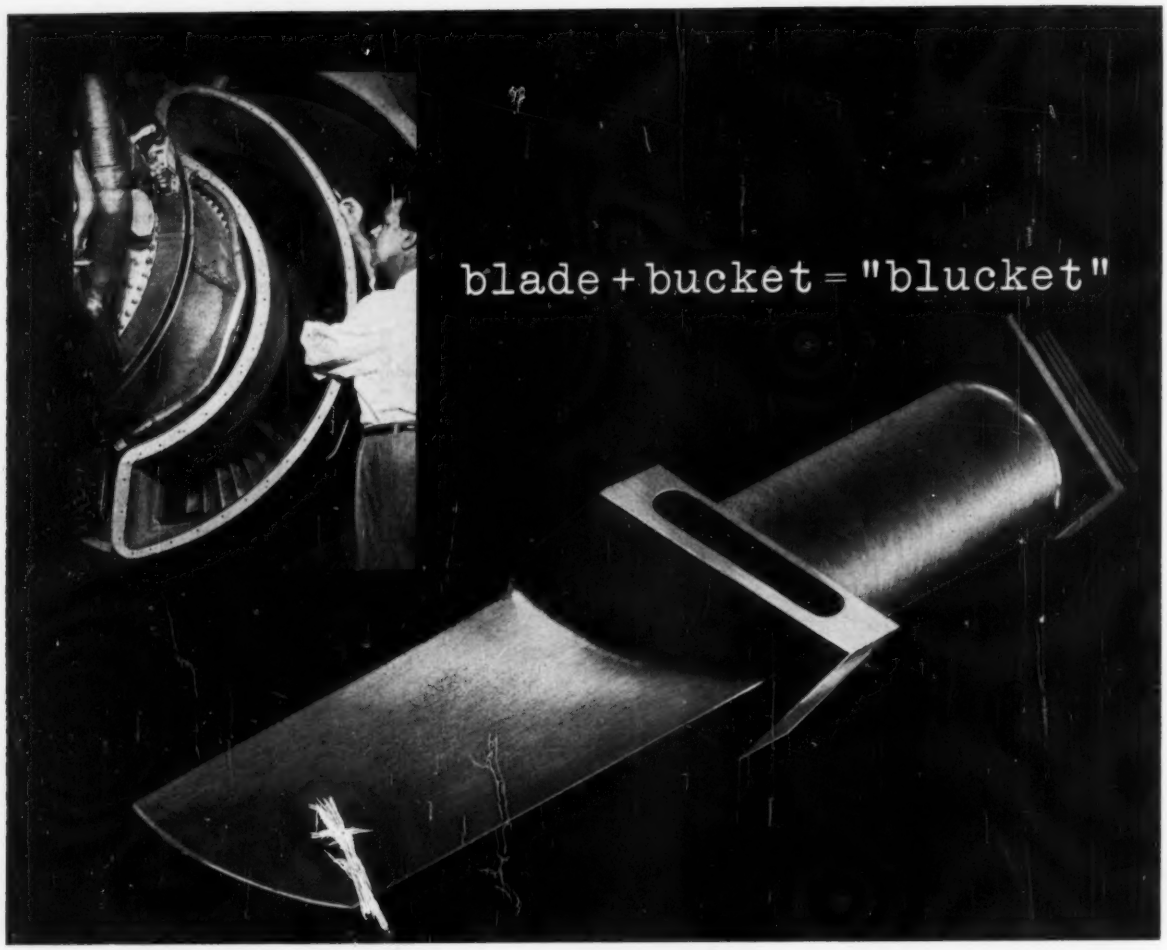
Genuine Chromel and Alumel are produced exclusively by

HOSKINS MANUFACTURING CO.

4441 Lawton Avenue • Detroit 8, Michigan

Custom Quality resistance, resistor and thermo-electric alloys since 1908

Circle 503 on Page 49-S



new design in *Carpenter* high temperature alloy V-57

Everything about this combination fan blade-turbine bucket is new except its predictable performance . . . a built-in characteristic of all Carpenter high temperature alloys.

V-57 is the super alloy now used to forge this unique new jet engine component. V-57 replaced A-286 (originally used) because of its superior mechanical properties at operating temperatures. Like all Carpenter vacuum melted metals, V-57 is produced with exclusive Carpenter quality controls that permit tighter forging tolerances, better machinability and improved cold forming properties.

Carpenter's VACUMELTROL® (induction vacuum) and CONSUMET® (consumable electrode) melting processes assure you more accurate forgings with better finishes, fewer rejects, faster production . . . and, most important . . . true predictable performance in your high temperature alloy components. Ask your Carpenter Representative for details.

Carpenter steel

you can do it ***consistently*** better with Carpenter Specialty Steels for specialists

The Carpenter Steel Company, Main Office and Mills, Reading, Pa.
Alloy Tube Division, Union, N. J.
Webb Wire Division, New Brunswick, N. J.
Carpenter Steel of New England, Inc., Bridgeport, Conn.

Circle 504 on Page 48-B

331. Ultrasonic Cleaning
Bulletin 60-1 "How to Clean Ultrasonically With Self Tuning". Autosonic tuners eliminate operator training and monitoring. *Powertron Ultrasonic Corp.*

332. Gold Plating
Literature from *Sel-Rex Corp.* describes processes for plating with gold, rhodium, platinum, palladium, silver and other alloys.

333. Glass Shot
Microbeads Inc. will send information and samples of "Glas-Shot", microscopic glass beads, for use with all types of wet or dry blast equipment.

334. Nickel Plating
Leaflet discusses "Kanigen" process for applying a hard corrosion resistant, nickel alloy coating without electricity. *General American Transportation Corp.*

335. Vapor Degreasing
Hooker Chemical Corp. has prepared Bulletin 70 on "Nialk" stabilizers and their advantages in vapor degreasing operations.

336. Selective Plating
Selectrons, Ltd. has issued an 8-p. pamphlet on high-speed selective plating which lists available equipment, techniques, and applications.

337. Hot-Dip Zinc Coating
Pamphlet from *Armco Steel* on "Zincgrip" coating for steel; protects against rust and corrosion at minimum cost.

338. Polishing Speed Calculator
Hanson-Van Winkle-Munning Co. will send disc calculator for determining surface speed of both buffing and polishing wheels.

Welding and Joining Equipment

339. Welding Stainless
The *McKay Co.* has prepared a 6-p. folder containing chemical and physical specifications on stainless steel electrodes.

340. "Squirtmobile"
Bulletin No. 5205.2 contains information on the operating features and construction details for a trackless carriage on a semi-automatic "Squirt" welder. *Lincoln Electric Co.*

341. Welding Equipment
Air Reduction Sales Co. has published a catalog describing its complete line of manual, semi-automatic, and automatic "Heliwelding" equipment.

342. Soldering Irons
4-p. folder, GEC-1545, discusses *General Electric's* line of industrial soldering irons for use on electronic equipment, meters and instruments.

343. Cutting Stainless Steel
Cost-saving potential and metallurgical advantages of cutting stainless steel plate by tungsten arc process described in illustrated folder from *Jessop Steel Co.*

344. Silver Brazing
Bulletin 20 gives the facts on silver brazing and its benefits—including details on alloys, heating methods, joint design and production techniques. *Handy & Harmon.*

345. Electron Beam Welder
The Model 2405 electron beam welder may solve your tough welding problems. Information from *NRC Equipment Corp.*

346. Stainless Overlay
Wall Colmonoy Corp. will send information on "Nicrocoat", a stainless coating for improving corrosion resistance.

347. Brazing Furnaces
Pacific Scientific Co. has a pamphlet on brazing and furnaces which go to 2350°F. and have up to 8,000,000 Btu. per hr. capacity.

348. "Guide to Better Welds"
80-p. booklet discusses causes and cures of common welding troubles, essentials for proper welding, and electrode selection. *Hobart Brothers Co.*

349. Combination Welders
Complete specifications on combination ac-dc welders, which work from single-phase service. *Miller Electric Mfg. Co.*

350. Metallurgy Courses
32-p. catalog describes courses available through Metals Engineering Institute. Individual home-study or in-plant "extension" courses include elementary metallurgy, heat treating, welding and foundry operations. *American Society for Metals.*

351. Brazing Flux
For high-quality brazed joints on a wide range of ferrous and nonferrous alloys, use "Aircosil No. 18" flux. *Air Reduction Sales Co.*

Inspection and Control Equipment

352. Information Searching
Brochure discusses documentation service which delivers the world's current metallurgical literature to you every two weeks in digest form. *American Society for Metals.*

353. Reference List
A 20-p. x-ray literature list of 376 papers from 1930 to 1960 will be sent by *Phillips Electronic Instruments.*

354. Metallographic Equipment
Catalog E232 from *Bausch & Lomb* presents line of metallographic equipment. Fast, dependable analyses can save you time and material.

355. Nondestructive Testing
Leaflet describes nondestructive and ultrasonic cleaning equipment and applications. *Curtiss-Wright Corp.*

356. Strain Gage Accelerometer
Bulletin 4202 contains information on "Type 4-202," the smallest temperature-compensated strain gage accelerometer in existance. *Consolidated Electrodynamics.*

357. Data Reduction
9-p. memorandum "Statistical Data Reduction and Control Systems" summarizes methods for increasing efficiency of data reduction and quality control systems. *Monitor Systems, Inc.*

358. "Testing U.S.A."
4-p. bi-monthly bulletin contains news of machines and test methods for all types of testing problems. *Testing Machines Inc.*

359. Inspecting Wire
Magnetic Analysis Corp. has released a pamphlet on a "Rototester", used for inspecting cold-drawn coiled wire up to 1 in. in diameter.

360. Metallurgical Microscopes
8-p. Booklet EM-960 sets forth information on metallurgical microscopes and accessories. *Elgeet Optical Co.*

361. Hardness Testers
Motorized "Kentrall" hardness testers reduce operator error and increase reproducibility of test results. Bulletin CRS 60 from *Torsion Balance Co.*

362. Universal Tester
10-p. Bulletin M-2 contains information

Circle appropriate number on Reply Card, p. 48B

need a
heat
stable
lubricant?

FLEXIMET PCM*

Here's a tough heat stable protective lubricant fortified with extreme pressure additives to promote optimum lubricity. The resulting coating provides good protection and "built-in" lubrication for finished rope or cable wire. Designed to remain stable after stress relief, heat treatment or patenting.

Use Fleximet PCM as received, directly in die box.

WRITE SWIFT FOR BULLETIN 46 and details on other FLEXIMET products

** A metallic base lubricant, fortified with additives including molydisulfide to provide EP properties.*

SWIFT & COMPANY
SOAP DEPARTMENT
4115 Packers Ave., Chicago 9, Illinois

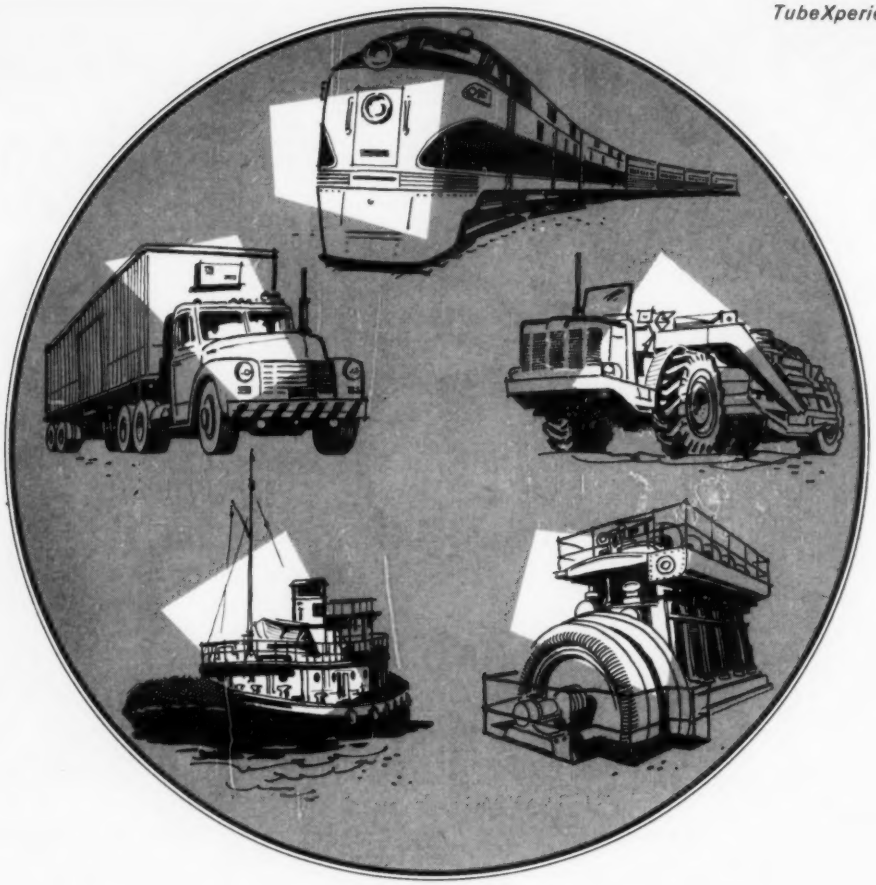
S-76

Swift
METALLIC COMPLEXES

106TH YEAR

Circle 505 on Page 48-B

TubeXperience in Action



Feedlines for hungry horsepower . . . diesel fuel injection tubing by Superior

Fuel injection systems are the heart of thousands of diesel-powered trucks, locomotives, roadbuilding equipment, electric generators, and marine power plants. The tubing that conveys the fuel from injection pump to nozzle assembly is an important component. It must resist the stresses of pressure and vibration, yet be ductile enough to be cold swaged and upset and be cold formed into loops and bends without excessive springback. It must have a clean ID, tremendous burst strength, and high fatigue resistance. Superior diesel fuel injection tubing is just such a premium product.

Type C-1008 and Type MT-1010 carbon steel tubing are most commonly specified for this application, but alloy and stainless steel tubing for pressures above 9000 psi and greater corrosion resistance is available. Superior also makes tubing for many other applications—supplies both general and special purpose tubing for aircraft, missiles, electrical, electronic, chemical, hydraulic, dairy and nuclear, to name a few. For complete information, write Superior Tube Company, 2008 Germantown Ave., Norristown, Pa.

SOME REASONS WHY SUPERIOR FUEL INJECTION TUBING IS A PREMIUM PRODUCT

- It will handle pressures to 9000 psi, is hydrostatically tested to various pressures according to specification
- It is cold drawn, dead soft annealed, and seamless
- It is ID conditioned to remove fissures and other defects
- It is free from ID radial cracks deeper than .005 in. or 5% of wall thickness, whichever is less
- It is annealed at finish in controlled atmosphere furnaces to produce a soft, ductile and scalefree material
- Fracture tests are performed when requested

Superior Tube

The big name in small tubing

NORRISTOWN, PA.

All analyses .010 in. to ⅜ in. OD—certain analyses in light walls up to 2½ in. OD

West Coast: Pacific Tube Company, Los Angeles, California • FIRST STEEL TUBE MILL IN THE WEST

Circle 506 on Page 48-B

on universal machine equipped for low-temperature testing. *Instron Engineering.*

363. Spectroscopic Electrodes

National Carbon Co. will send details on preformed electrodes for spectroscopic applications.

364. Control Instruments

Illustrated brochure from the *Bristol Co.* on complete line of pyrometer instruments and accessories for the metal industry.

365. Cut-Off Machine

Buehler Ltd. will send information on a "No. 1000AB" cut-off machine with a 12 in. abrasive wheel and built-in cooling system.

366. Direct "Psi" Readings

Flyer from *Scott Testers, Inc.* offers information on a compensator which automatically adjusts test recordings for dimensional changes in specimen thickness, width, or diameter.

367. Portable Testing Unit

The *King Tester Corp.* has published a pamphlet on their portable tester. One test head fits many inexpensive adapters.

368. Ultrasonic Testing

Curtiss-Wright Corp. will send information on their "Immerscope". Defects as small as 0.0156 in. can be detected in steel parts.

369. Accessories Catalog

The *Beckman Scientific Instruments Div.* offers a 14-p. accessories catalog No. 738 for their "DK Spectrophotometers".

370. Gamma Radiography

Flyer from *Radionics Inc.* gives details on "60 Series" panoramic radiography cameras.

371. Fatigue Testing

Bulletin BM-2050 discusses high-temperature, high-speed, high-capacity fatigue testing with 850 in.-lb. rotating beam machine. *Budd Instruments Div.*

372. Horizontal Goniometer

The *Radio Corp. of America* has published detailed information on their x-ray diffraction and spectroscopy equipment. Six different functions by adding accessories.

373. Recording Unit

Tinius Olsen Testing Machine Co. will send pamphlet discussing portable "XY Strip Chart Recorder". A series of tension, compression, or cycling tests can be recorded in rapid succession on same chart.

374. Superficial Hardness

Catalog RT-58 gives the facts on a superficial hardness tester, as well as a full line of Rockwell hardness testers. *Wilson Mechanical Instrument Div.*

375. Eddy Current Inspection

The *Budd Instruments Div.* has prepared bulletin IM-1000, which discusses "Model 302 Metrol Radac", a multiple frequency eddy current inspection unit.

376. Radiographic Inspection

Get the full story from *Picker X-Ray Corp.* on their Cobalt-60 "Cyclops" radiographic instrument. About one-fourth the price of equivalent energy x-ray equipment.

378. Hardness Testing

Clark Instrument, Inc. has published reference book containing information on hardness testing. Hardness conversion chart also available.

379. Spectrochemical Instruments

Baird-Atomic, Inc. has literature describing line of spectrochemical instruments, including direct-reading spectrometers and infrared spectrophotometers

380. Mass Spectrometer

8-p. Bulletin 21110 summarizes specifications and applications for the "Type 21-110" mass spectrometer. *Consolidated Electrodynamics Corp.*

381. Portable Tester

Catalog sheet from *Detroit Testing Machine Co.* describes compact, precision tensile tester. . . . 4000 lb. capacity.

Production and Casting

382. Die Casting Machines

The Cleveland Automatic Machine Co. has published a 12-p. brochure reviewing their line of hot and cold chamber hydraulic die casting machines, in capacities from 100 to 2000 lb.

383. Vacuum Furnaces

The *Kinney Vacuum Div.* will send information on high-vacuum furnaces, which will handle loads up to 1000 lb. in steel (2200 lb. uranium) at temperatures up to 3400°F.

384. Ferroalloys

Vanadium Corp. of America has prepared an 8-p. brochure listing chemical composition and applications for ferroalloys and metals—aluminum, boron, chromium, columbium, manganese, silicon, titanium and vanadium.

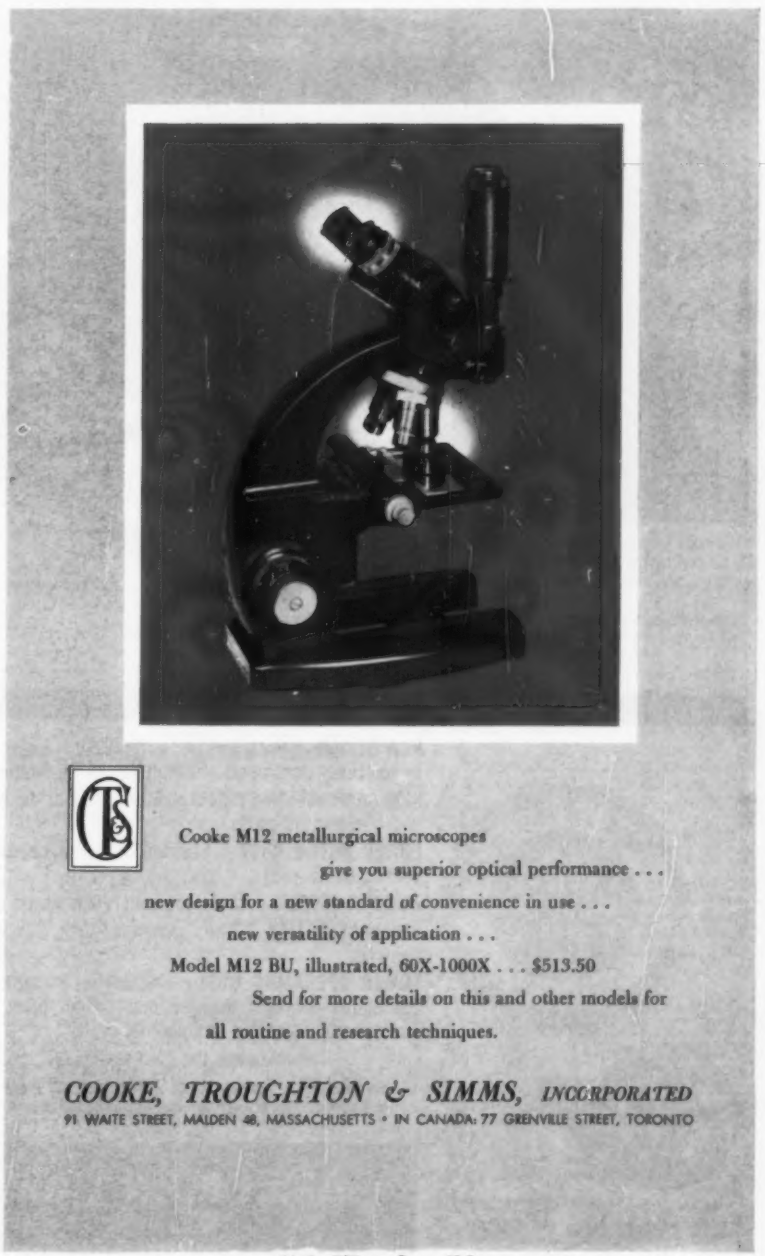
385. Vacuum Equipment

Pamphlet ZBW-60 from the *Zak Machine Works, Inc.* illustrates their vacuum equipment for special applications in melting, annealing, and processing.

386. Heat Treatment of Stainless

24-p. research report "Heat Treatment and Properties of Cast, Hardenable Stainless Steels" is offered by *WaiMet Alloys*

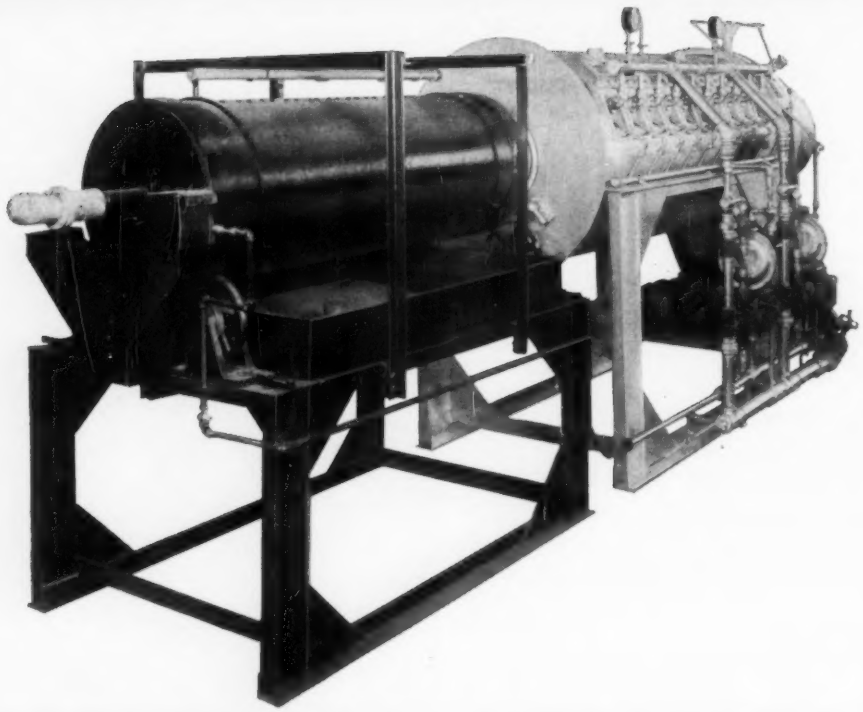
Circle appropriate number on Reply Card, p. 48B


Cooke M12 metallurgical microscopes
give you superior optical performance . . .
new design for a new standard of convenience in use . . .
new versatility of application . . .
Model M12 BU, illustrated, 60X-1000X . . . $513.50
Send for more details on this and other models for
all routine and research techniques.
COOKE, TROUGHTON & SIMMS, INCORPORATED
91 WAITE STREET, MALDEN 48, MASSACHUSETTS • IN CANADA: 77 GRENVILLE STREET, TORONTO

Circle 507 on Page 48-B

Small Parts Annealing at Low Cost with an

AGF *Automatic Rotary Furnace*



NEW DESIGN... Rotary Retort with integral water jacketed cooling section—parts remain in positively controlled atmosphere during heating and cooling.

NEW COMBUSTION SYSTEM... 600° to 1800°F. operation permits processing both ferrous and non-ferrous parts.

LOWER INITIAL COST... Standardized designs result in a lower furnace cost which AGF passes on to you!

BUILT-IN FEEDER... Saves the several thousand dollar cost of a separate feeding device.

COMPACT DESIGN... Uses minimum floor space—far less than any type of conveyor furnace.

LOWER OPERATING COST... Automatic feeder hopper reduces work handling costs—Eliminates conveyor maintenance—alloy retort, with integral spiral, positively conveys work through heating and cooling cycle.

Investigate the cost-saving AGF potential... Details on request.

Quality construction and 82 years of furnace building experience assure you of a furnace with long and trouble-free operating life.

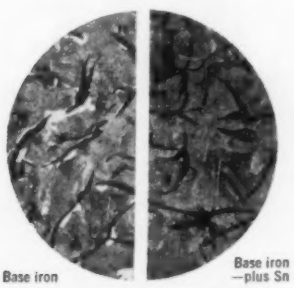
AMERICAN GAS FURNACE CO.
AMERICAN GAS FURNACE CO. 82 YEARS OF PIONEERING 1878 1958 ELIZABETH, N. J.
AMERICAN GAS FURNACE CO. PIONEERS 1878 CODE OF ETHICS SIGNER

AMERICAN GAS FURNACE CO.
1002 LAFAYETTE STREET — ELIZABETH 4, N. J.

Circle 508 on Page 48-B

Straits Tin Report

Tin reduces wear—The addition of up to 0.1% tin has a marked effect in eliminating ferrite from the matrix of both gray and nodular irons, producing a wear-resistant fully pearlitic matrix.



Effect of tin on pearlite in microstructure of hypo-eutectic cast iron bar, 1.2-in. dia.

The amount of tin added to cast iron sections up to 3 in. thick is not critical. A reasonable excess does not produce any massive cementite or affect mechanical properties.

Organic compounds of tin stabilize vinyl chloride polymers to inhibit color at high temperature and to protect against decomposition during processing and degradation in service.

Low linear contraction is a property of high tin content die-casting alloys. Tin alloys shrink very little, permitting close tolerances and very thin walls in such typical small castings as pinions, numbering machine wheels, dashpots of electrical instruments, and gas meter grid valves.

FREE Bulletin

Write today for a free subscription to TIN NEWS—a monthly bulletin on tin supply, prices and new uses.

The Malayan Tin Bureau
Dept. T-25A, 2000 K Street, N.W., Washington 6, D.C.

Circle 509 on Page 48-B

Div. Alloys include martensitic and precipitation hardening types.

387. Vacuum Measurement
Bulletin 3294B-05 discusses ways of using "Autovac" vacuum gages. Continuous reading from 100 mm. to 1 micron Hg. *Consolidated Vacuum Corp.*

388. Ductile Iron
Bulletin 131-B discusses ductile iron and includes a description of facilities and quality control procedures at *Brillion Iron Works.*

389. Nickel For Alloying
Illustrated brochure from *Sherritt Gordon Mines Ltd.* contains information on nickel briquets or powder for faster, easier alloying.

390. Sintering Furnaces
Bulletin No. 603 describes the advantages, physical properties and applications of powdered metal parts, and illustrates different types of sintering furnaces. *Electric Furnace Co.*

391. Pattern Wax
Alexander Saunders & Co. will send a chart which gives expansion and cooling characteristics of their pattern wax.

392. Ductile Iron Castings
Morris Bean & Co., producers of high-quality aluminum and ductile iron castings, will send their "Resources and Capabilities" booklet.

393. Graphite Electrodes
Technical data sheets from *Great Lakes Carbon Corp.* contain complete information on graphite electrode properties.

394. Control Motors
Minneapolis-Honeywell has published data on "Actionator" heavy-duty electrical control motors for industrial valve and damper applications.

395. Industrial Blowers
Catalog #126B contains specifications on industrial blowers, available in standard capacities of ½ to 1000 hp., up to 20,000 cfm., and 4 oz. to 10 lb. pressure. *Spencer Turbine Co.*

396. Atmosphere Generators
Get the full capacity, and the dryness and purity you specified in packaged gas atmosphere generator systems. Literature from *Gas Atmospheres Inc.*

397. Nickel Briquets
Illustrated brochure discusses low-hydrogen nickel briquets of special powders. *Foote Mineral Co.*

398. Insulating Firebrick
The *Babcock & Wilcox Co.* will send catalog R-2-H describing light weight insulating firebrick.

399. Induction Melting
Bulletin 70 contains complete information on induction melting equipment. *Inductotherm Corp.*

401. Castable Linings
Using "Lumnite" calcium-aluminate cement, monolithic linings can be cast in place without anchors or reinforcing mesh. *Universal Atlas Cement Div.*

402. Vacuum Pumps
F. J. Stokes Corp. will send pamphlet discussing "Series H Microvac" pumps, and a free vacuum-slide calculator.

403. Nitriding Process
14-p. Bulletin No. TM-1 from *Armour Industrial Chemical Co.* covers case hardening of metals by nitriding with an anhydrous ammonia atmosphere.

404. Core Binders
Folder issued by *Corn Products Sales Co.* details applications for "Dexacor" baked-strength core binder (in combination with core oils).

HARRIS CHILLING HELPS MAKE PRECISION THEIR MIDDLE NAME AT . . . .

MPB

Miniature Precision Bearings, Inc., Keene, N. H., achieves dimensional stability in their tiny bearings through chill-treating AISI-440-C S.S. and SAE 52100 steel in their Harris Chilling Machine. The chilling process, at –120°F., minimizes molecular rearrangement and also effects further transformation from austenite to martensite.

MPB also stabilizes tools and gages through Harris chill-treatment of alloy tool steels and high speed steels used in their fabrication.

Harris Model 5L-B2 Refrigeration Machine chill-treats steel at MPB for dimensional stability in precision bearings, tools and gages.

Requiring the utmost in dimensional stability, MPB bearings are designed to operate at temperatures from –65° to +150°F. In smaller sizes, 1000 MPB bearings weigh only 3.3 oz. Largest MPB part is the outer ring of a ⅜ inch ball bearing. The company has been so successful in living up to its middle name, "Precision," that it was chosen one of the top ten plants in the U.S. by the magazine, "Factory Management," in 1957.

The Company's General Marketing Manager, Mr. R. I. Kern, testifies that their Harris Chilling Machine effectively speeds transformation of the steels, gives more than adequate temperature control within 5°F., and offers easy accessibility for operation and adjustment.

ASK HOW CHILLING CAN CUT YOUR COSTS, AND IMPROVE YOUR PRODUCT . . . NO OBLIGATION FOR OUR ADVICE.

HARRIS MANUFACTURING CO., INC.

306 RIVER ST., CAMBRIDGE 39, MASS.
Our 27th Year as Specialists in Refrigeration Engineering, Manufacturing, Service

Circle 510 on Page 48-B

Strand Annealers

30-KW Drever 12 tube furnace with 9 foot heating chamber. Capacity 85 lbs./hour (.020" wire); speed 50 to 200 feet per minute.

FOR

Bright Annealing

STAINLESS WIRE

Clean Bright high quality stainless or alloy wire is heat treated economically in Drever Continuous Bright Annealing Furnaces.

Versatility of production is possible by design of pay-off and recoiling mechanisms. Each block is driven individually, thus wire of different diameters may be annealed at varying speeds at the same time.

Proper atmosphere equipment is supplied depending on type of wire to be bright annealed.

Write for further details on this or other type of Drever Furnaces.

ENGINEERING AND MANUFACTURING FACILITIES AROUND THE WORLD THROUGH ASSOCIATES IN FRANCE, GREAT BRITAIN, GERMANY, ITALY, AND JAPAN

DREVER COMPANY

BETHAYRES, PA.

Circle 511 on Page 48-B

The American Society for Metals and Metal Progress Serve 32,000 member-readers in 11 major areas of the metals industry.

The ASM is the communications center for technical information wherever metals are produced, processed, fabricated, designed, tested and applied. Metal Progress, monthly engineering magazine of the Society, reports on engineering developments in these 11 major technological areas:

FERROUS METALS: Alloy, Carbon, Free Machining, Stainless Steels, Hot and Cold Finished Bars.

NONFERROUS METALS: Aluminum, Beryllium, Brass, Bronze, Columbium, Copper, Lead, Magnesium, Molybdenum, Monel, Nickel, Rare Earths, Tantalum, Titanium, Tungsten, Zinc, Zirconium.

HEAT- AND CORROSION-RESISTANT AND ELECTRICAL MATERIALS: Special Alloys; Carbon, Graphite; Ceramics, Cermets, Thermal Insulating and Special Electrical Materials.

RADIATION AND NUCLEAR MATERIALS & EQUIPMENT: Metallic and Non Metallic Reactor Materials, Fuel Elements, Pressure Vessels, Control Elements, Related Equipment.

TOOL MATERIALS, CUTTING AND FORMING EQUIPMENT: Abrasives; Carbides; Coolants, Oils and Lubricants; Arc and Gas Cutting Equipment, Saws; Forging, Pressing, Extruding, Chemical Milling, Slitting, Straightening, Spinning and Explosive Forming Equipment; Tool and Die Steels, Plastic and Other Short-Run Die Materials.

INDUSTRIAL HEATING EQUIPMENT AND SUPPLIES: Atmosphere Generators and Gases; Commercial Services; Furnaces; Controls, Indicaters and Recorders; Induction, Flame and Salt Bath Equipment; Ovens; Cryogenic Equipment; Pyrometers; Quenches; Samplers and Analyzers; Trays, Refractory Parts.

CLEANING AND FINISHING EQUIPMENT AND SUPPLIES: Alkaline Cleaning, Pickling, Degreasing, Descaling, Buffing, Polishing, Blasting, Plating; Porcelain Enameling, Purifying; Painting Equipment and Supplies; Rust Preventives; Abrasives.

WELDING AND JOINING EQUIPMENT AND SUPPLIES: Gas, Resistance and Arc Welding Equipment and Supplies; Electrodes; Adhesives, Fasteners; Hard Surfacing, Brazing and Soldering Equipment and Supplies.

INSPECTION AND CONTROL EQUIPMENT AND SUPPLIES: Microscopes and Attachments; Analytical and Mechanical Equipment; Gages, Comparaters, Hardness Testers, Nondestructive, Electronic and Other Scientific Inspection Equipment.

PRODUCTION AND CASTING EQUIPMENT AND SUPPLIES: Electric and Vacuum Furnaces and Equipment; Refractories; Ferro Alloys; Foundry Irons and Coke; Rare Earths; Alloying and Refining Agents; Annealing, Soaking and Sintering Furnaces; Rolling Equipment; Industrial Gases; Foundry Equipment and Supplies.

PARTS, FORMS AND SHAPES FOR DESIGN AND APPLICATIONS: Castings (Malleable, Gray Iron, Steel, Nonferrous), Forgings, Extrusions, Powder Metal Parts, Springs, Stampings, Tubing, Weldments, Wire.

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January, 1961 issue
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January, 1961 issue
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Metal Progress January, 1961 issue

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Metal Progress January, 1961 issue

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Name: _____

Title: _____

Company: _____

Address: _____ (Street)

(City) _____ (Zone) _____ (State)

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☐ If not an ASM member, please check box for complete information on membership advantages.

Cards not valid without company names, or if used after March 31, 1961.

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Catalogs and bulletins, new products and services and most advertisements in Metal Progress are numbered. To receive more information, circle the appropriate numbers on one of these postage paid cards. Editorial reprints will be sent free as long as they last.

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Please Include Your Name and Address!

Your best move is to UNITRON...

for a COMPLETE LINE of METALLURGICAL MICROSCOPES!

UNITRON'S Complete Line of Metallurgical Microscopes and Accessories covers the needs of Research, Industry and Education.

Quality optics . . . advanced optical and mechanical design . . . unique and convenient operational features . . . budget prices . . . free trial period — these, together with proven performance are the reasons why . . .

THE TREND IS TO UNITRON!

Circle 428 on Page 48-B

UNITRON

INSTRUMENT COMPANY • MICROSCOPE SALES DIV.
66 NEEDHAM ST., NEWTON HIGHLANDS 61, MASS.

Please rush UNITRON's Microscope Catalog 2-K

Name_____

Company_____

Address_____

City_____ State_____

Timken® Seamless Steel Tubing from your Steel

CUTS YOUR INVENTORY COST, SAVES YOU STORAGE SPACE—GIVES YOU COMPLETE SERVICE, FAST DELIVERY

Call these Steel Service Centers for Timken Seamless Steel Tubing—

LOCATION	STEEL SERVICE CENTER
ALABAMA	
Birmingham	O'Neal Steel, Inc.*†
ARIZONA	
Phoenix	Earle M. Jorgensen Co.*†•
CALIFORNIA	
Los Angeles	Allen-Fry Steel Company*
	Baker Steel & Tube Co. •
	Coulter Steel & Forge Co.*†
	Earle M. Jorgensen Co.*†
	Kilsby Tube Supply, Division of Republic Supply Co. of Calif.•
	Joseph T. Ryerson & Son, Inc.*•
	Service Steel Division Van Pelt Corp.•
	Tube Distributors, California, Inc. •
	Tubesales•
Oakland	Coulter Steel & Forge Company (Emeryville)*†
	Earle M. Jorgensen Co.*†
	Joseph T. Ryerson & Son, Inc.*•
San Francisco	Baker Steel & Tube Co.•
	Earle M. Jorgensen Co.*†
	A. Milne & Co., Inc. (Burlingame)†
COLORADO	
Denver	Earle M. Jorgensen Co.*†•
CONNECTICUT	
Windsor	SAE Steels, Inc.*
GEORGIA	
Atlanta	A. Milne & Co., Inc.†
	O'Neal Steel, Inc.*†
HAWAII	
Honolulu	Earle M. Jorgensen Co.*†•
ILLINOIS	
Chicago	Chicago Tube and Iron Co.•
	Hy-Alloy Steels Co.*•
	A. Milne & Co., Inc. (Melrose Park)†
	The Peninsular Steel Co.†
	Joseph T. Ryerson & Son, Inc.*•
	Service Steel Division Van Pelt Corp.•
INDIANA	
Ft. Wayne	Tubular Sales•
Indianapolis	The Peninsular Steel Co.†
KANSAS	
Wichita	Earle M. Jorgensen Co.*†•
LOUISIANA	
New Orleans	Earle M. Jorgensen Co.*†•
MASSACHUSETTS	
Boston	A. Milne & Co., Inc.†
	Joseph T. Ryerson & Son, Inc. (Allston)*•
MICHIGAN	
Detroit	Alloy Steels, Incorporated†
	A. Milne & Co., Inc.†
	The Peninsular Steel Co.†
	Joseph T. Ryerson & Son, Inc.†•
	Service Steel Division Van Pelt Corp.•
	Tubular Sales•
Grand Rapids	The Peninsular Steel Co.†
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St. Paul	Paper, Calmenson & Company*
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Jackson	O'Neal Steel, Inc.*†
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St. Louis	Ford Steel Company†
	Joseph T. Ryerson & Son, Inc.*•
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Elizabeth	A. B. Murray Co., Inc.•
Englewood	Tubesales•
Jersey City	Joseph T. Ryerson & Son, Inc.*•
Kenilworth	A. Milne & Co., Inc.†
Linden	Bowsteel Distributors Corporation*
Newark	Faitoute Iron & Steel Company, Inc.*
NEW YORK	
Buffalo	The Peninsular Steel Co. (Tonawanda)†
	Joseph T. Ryerson & Son, Inc.*•
	Service Steel Division Van Pelt Corp.•
Garden City (L.I.)	Tube Distributors Co., Inc.•
New York	A. Milne & Co., Inc.†
NORTH CAROLINA	
Charlotte	Joseph T. Ryerson & Son, Inc.†•
OHIO	
Akron	The Peninsular Steel Co.†
Cincinnati	Ford Steel Company†
	Joseph T. Ryerson & Son, Inc.†•
	SAE Steels, Inc.*
	Service Steel Division Van Pelt Corp.•
Cleveland	A. Milne & Co., Inc.†
	The Peninsular Steel Co. (Bedford Heights)†
	Joseph T. Ryerson & Son, Inc.*•
	SAE Steels, Inc.*
Dayton	Alloy Steels, Incorporated†
	A. Milne & Co., Inc.†
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OKLAHOMA	
Tulsa	Earle M. Jorgensen Co.*†•
OREGON	
Portland	Pacific Machinery and Tool Steel Co.†
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Bristol	A. B. Murray Co., Inc.•
Butler	Keystone Pipe & Supply Co.•
Carnegie	A. Milne & Co., Inc.†
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McKeesport	A. B. Murray Co., Inc.•
Philadelphia	Capitol Pipe & Steel Products, Inc.•
	A. Milne & Co., Inc.†
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Chattanooga	O'Neal Steel, Inc.*†
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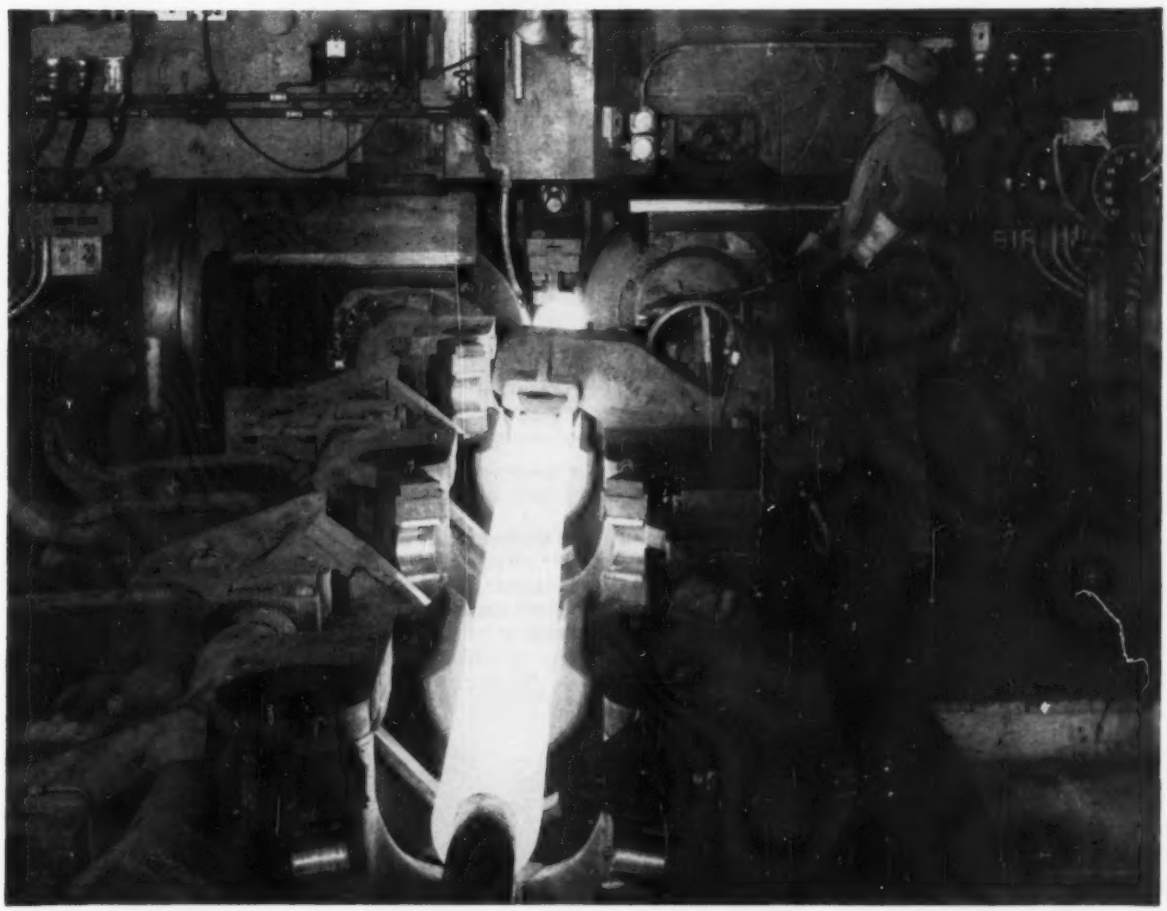
	Vanadium-Alloys Steel Canada, Limited†
Toronto, Ontario	Drummond, McCall & Co., Limited•
	Vanadium-Alloys Steel Canada, Limited†

* Alloy Steel Bars and Billets † Graphitic Tool Steels • Seamless Steel Tubing

Service Center gives you all these advantages

SUPPLIES YOU WITH HIGHEST, FINE FORGED QUALITY TUBING—TIMKEN® SEAMLESS STEEL TUBING

Available in carbon, alloy and stainless grades



When you buy Timken® seamless steel tubing you get the finest made. At the Timken Company steel mill, the piercing process (shown above) gives the tubing its fine forged quality. Every order of Timken steel tubing, graphitic tool steels, alloy steel bars or billets is quality controlled, rigidly inspected from start to finish. Quality is assured from heat to heat, tube to tube, order to order.

And you can save in many ways when you buy Timken steel tubing or other Timken steel products from your Steel Service Center. It warehouses the stock, saving you from tying up capital in inventory. You can put your space to more productive use. Your steel can be prepared ready for use, cutting your processing cost. And you're assured of fast, dependable delivery.

What's more, when you buy Timken steel you can always benefit from technical help on your steel problems, if you wish, from the Timken Company's own steel experts. For the most for your steel money, specify "Timken" at your Steel Service Center. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable: "TIMROSCO." Makers of Tapered Roller Bearings, Fine Alloy Steel and Removable Rock Bits.

TIMKEN®
***Fine Alloy* STEEL**

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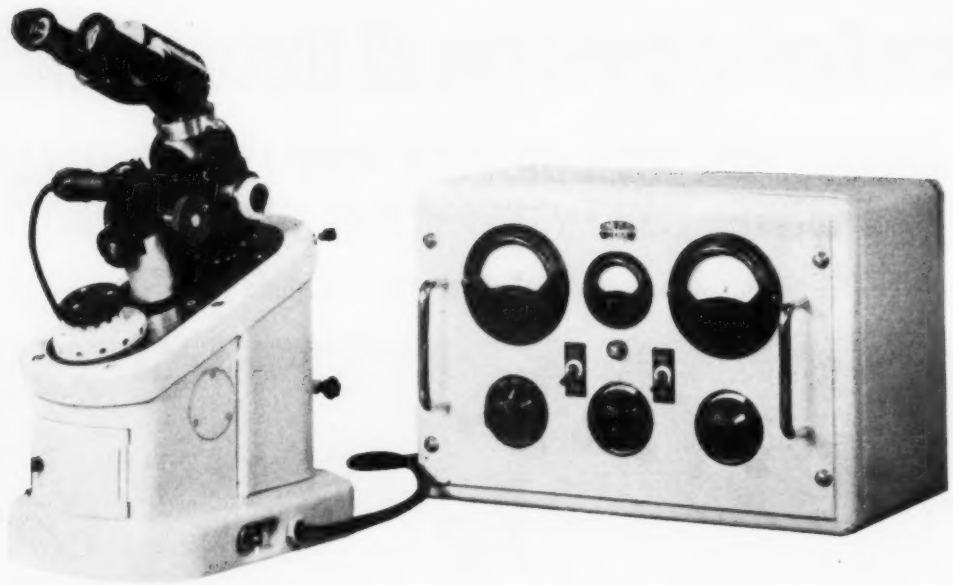


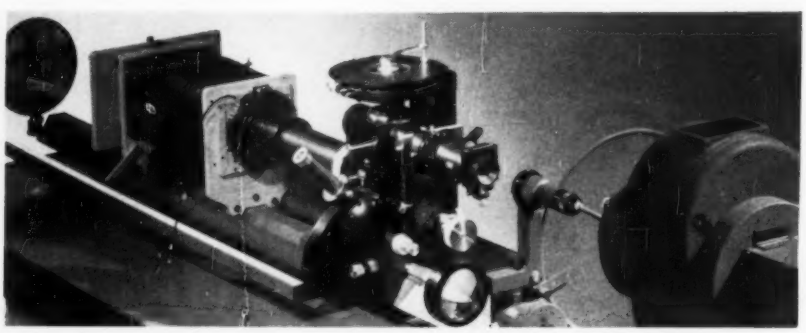
CARL ZEISS JENA

companion of scientific progress for six generations

ELECTROLYTIC POLISHER

The Carl Zeiss Jena Electrolytic Polisher is the only instrument in the world permitting constant observation of the etching process. Elimination of stop-and-start, trial-and-error specimen preparation results in tremendous time saving and increased accuracy.

- Electrolytically removes layers from specimen surface under controlled conditions
- Polisher is completely closed during operation protecting user from contact with electrolyte or live electrical parts
- Automatic safety interlock stops electrolytic action when unit is opened
- Specimen size up to 30 mm. high x 100 mm. diameter
- Microscope provides 210X magnification
- Easily adaptable to photomicrographic studies
- External power supply unit included



NEOPHOT—Research Metallographic Microscope

Modern, incident-light, photo-microscopy has a strong ally in the Carl Zeiss Jena Neophot, an extremely accurate research metallograph priced as a routine instrument.

- Optical system corrected to produce highest resolution and flatness of field obtainable
- Highly flexible . . . bright field, dark field, polarization, phase contrast
- Three individual photographic systems permit a succession of imaging scales from 0.5:1 to 1600:1
- Microhardness Tester (model D32) available as accessory unit

Complete information may be obtained from your local Carl Zeiss Jena instrument dealer or by writing: ***Dept. MP 1/61***

ERCONA Ercona Corporation, Scientific Instrument Division, 16 West 46th Street, New York 36, N.Y.
In Canada: Jena Scientific Instruments Ltd., 1437 MacKay Street, Montreal, Quebec

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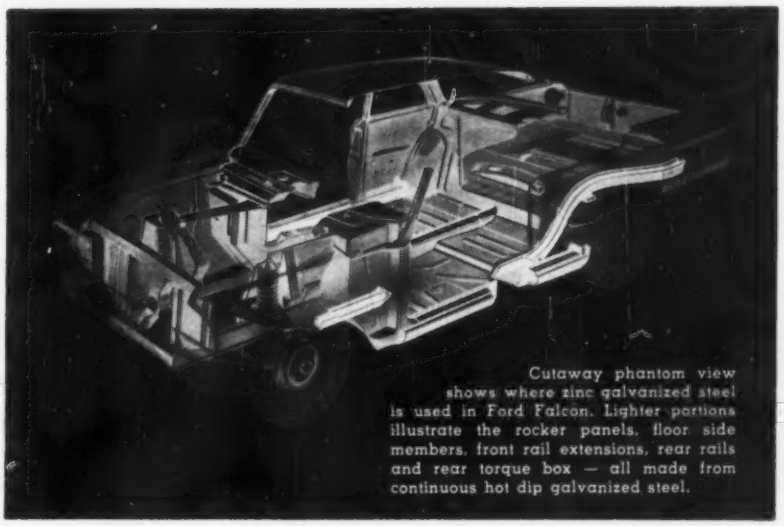
ZINC GALVANIZING

Protects Vital Body Parts In FORD MOTOR CO.'s Compact Cars



Cutaway phantom view shows where zinc galvanized steel is used in Ford Falcon. Lighter portions illustrate the rocker panels, floor side members, front rail extensions, rear rails and rear torque box — all made from continuous hot dip galvanized steel.

COMPARATIVE TESTS PROVE GALVANIZED STEEL BEST CORROSION GUARD FOR VULNERABLE PARTS IN UNITIZED CONSTRUCTION

After 2½ years of evaluation tests, FORD MOTOR COMPANY'S Advanced Body Development decided galvanized steel was the best material for protecting unitized bodies against corrosion.

The box type construction of unitized bodies makes corrosion a critical problem because moisture and road salts become trapped in vital underbody parts. Zinc galvanized steel is expected to give these parts 2½ to 3 times longer life than conventional low carbon steel. This would mean that they will be corrosion-free for 10 to 12 years under normal use.

This is the reason why Ford and other auto makers are now using galvanized steel for the basic framing members of the new unitized bodies.

ANOTHER EXAMPLE OF THE VERSATILITY OF CONTINUOUS GALVANIZED STEEL

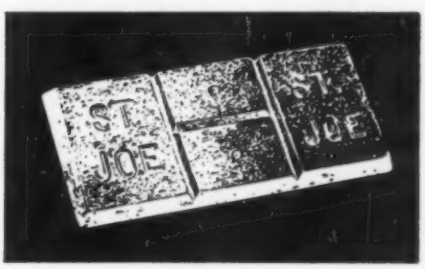
The use shown here is one of a wide variety of applications where continuous galvanized sheet provides the successful combination of protection plus formability. This pre-protected metal can withstand torturous deformation without losing its corrosion-resistance. The zinc coat flows with the base metal — does not chip, flake, powder or peel under severe forming operations.

St. Joseph Lead Co. supplies zinc "electronically-matched" to virtually any specifications which operators of continuous galvanizing lines may require.

ST. JOSEPH LEAD CO.

ST. JOE

250 Park Avenue, New York 17, N. Y.



ZN-166

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KNOW YOUR ALLOY STEELS . . .

This is one of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many who may find it useful to review fundamentals from time to time.

Methods of Carburizing Alloy Steels

Carburizing is a means of impregnating the surface of steel with carbon, usually to very limited depths. Its purpose is to provide a hard, wear-resisting "case," or outer shell. Alloy steels, correctly handled, can be case-hardened without sacrificing desirable core properties.

There are three types of carburizing in general use:

Liquid Carburizing—The medium here is a hot-salt bath composed basically of cyanide compounds. The steel is immersed in the bath, the period of immersion depending upon the analysis of the steel and the depth of case desired. Liquid carburizing is a convenient method of producing thin, hard, wear-resisting cases, generally within the depth range of 0.02 to 0.03 in. However, deeper cases may be obtained, the actual depths depending upon economics and end uses.

Gas Carburizing — This method employs a furnace in which a carbonaceous atmosphere is created; i.e., gases that are high in carbon components, or those containing carbon. Steel subjected to gas carburizing can be case-hardened to depths generally ranging from 0.01 to 0.04 in. When quenching takes place immediately after carburizing, distortion can be kept to a minimum.

Pack Carburizing — Where the pack method is used, the parts to be carburized are buried in a container of dry carbonaceous materials. The container is sealed tight to prevent the infiltration of air, placed in a furnace and kept there for eight hours or more, the actual time depending upon the depth of case desired. Pack carburizing is particularly suitable where a deep case is essential (0.06 in. and over), although medium cases in the 0.04-to-0.06-in. range are possible.

This series of alloy steel advertisements is now available as a compact booklet, "Quick Facts about Alloy Steels." If you would like a free copy, please address your request to Publications Department, Bethlehem Steel Company, Bethlehem, Pa.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.
Export Sales: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

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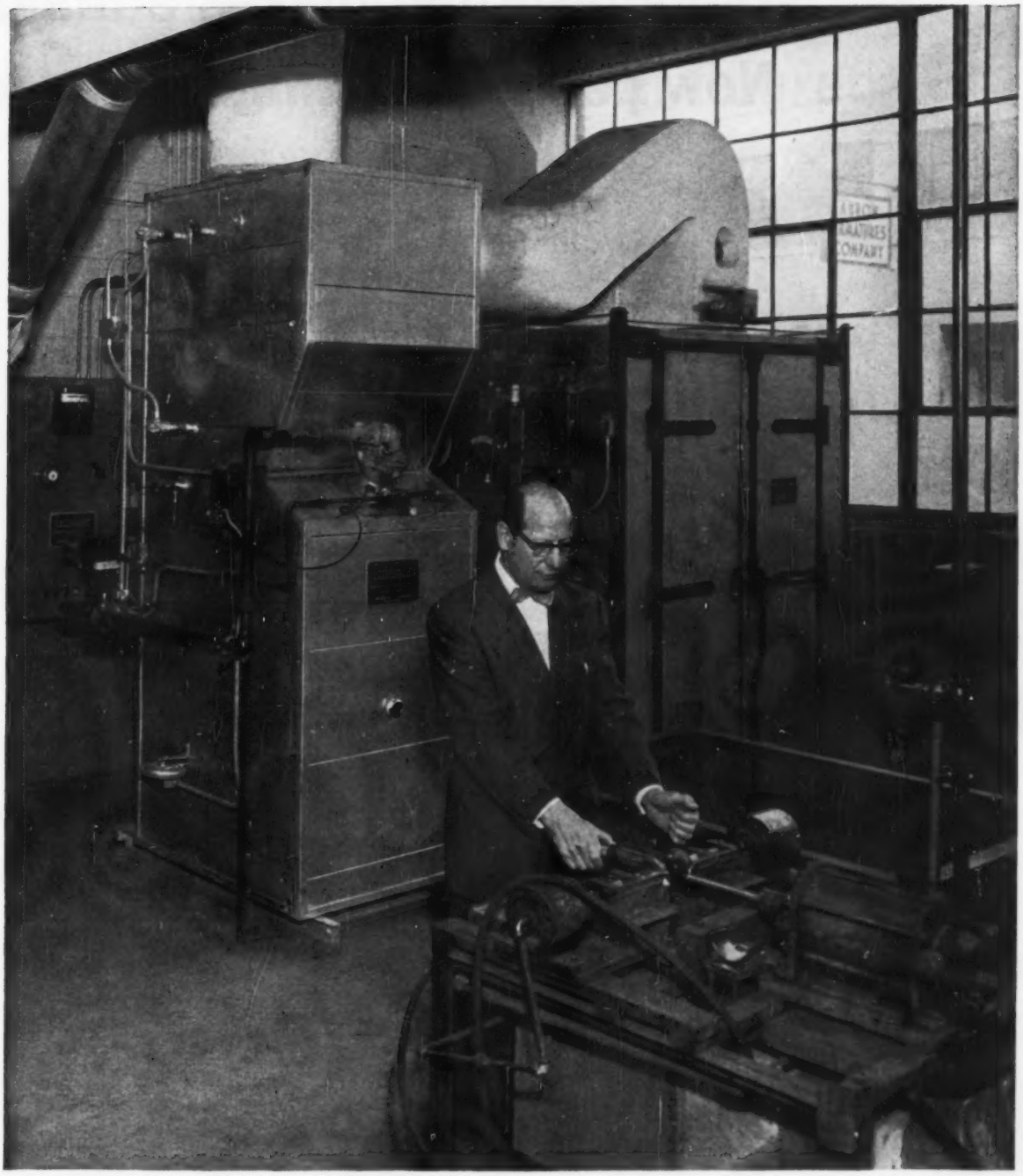

"Only GAS gives quick, controlled, complete combustion"

Albert Holzwasser, President, Arrow Armatures, Boston

"Arrow Armatures is the largest rebuilder of automobile generators in the East. One of the important steps in rebuilding generators is burning the old insulation from the armature before it is rewound. Because gas gives quick heat that can be accurately controlled, it answers our need perfectly.

"We also have a gas-fired catalytic combustion unit to incinerate the smoke and fumes produced in burning off this insulation. Together these units give us complete, clean combustion with no smoke control problems," states Albert Holzwasser, President.

Quick, controlled, complete combustion—and the many other advantages of gas—can be yours, too. For technical information, see your Gas Company's Industrial Sales Engineer. He can show you the economies and results you'll get with modern industrial gas equipment. *American Gas Association.*

FOR PRECISE CONTROL, GAS IS GOOD BUSINESS!

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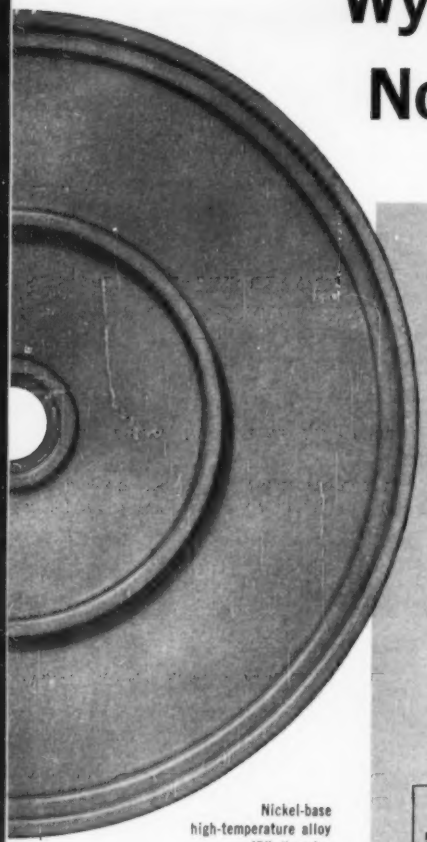
Wyman-Gordon makes a major
Now parts are being forged in



Nickel-base
high-temperature alloy
45" diameter
520 pounds

BROAD RANGE OF GAS TURBINE COMPONENTS ALSO BEING PRODUCED IN:

- Low-Alloy, High-Strength Steels
- Intermediate-Temperature Alloys
- Titanium and Refractory Metals
- Aluminum and Magnesium

High-strength steel
19" diameter
143 pounds

PHYSICAL PROPERTIES

	ALLOY*	TEST TEMPERATURE °F.	HEAT TREAT	GUARANTEED MINIMUM ULTIMATE TENSILE STRENGTH PSI	GUARANTEED MINIMUM 0.2% YIELD STRENGTH PSI	GUARANTEED MINIMUM ELONGATION %	TYPICAL VALUES ULTIMATE TENSILE STRENGTH PSI	TYPICAL VALUES 0.2% YIELD STRENGTH PSI	TYPICAL VALUES ELONGATION %
TENSILE AND YIELD STRENGTHS	Waspaloy	RT	A	175,000	120,000	15.0	194,000	136,000	24.0
		1000	A	162,000	112,000	13.0	175,000	124,000	23.0
	René 41	RT	B	180,000	132,000	12.0	200,000	150,000	15.0
		1400	B	135,000	115,000	13.0	145,000	125,000	18.0
	Astroloy	RT	C	190,000	138,000	10.0	205,000	152,000	12.0
		1400	C	150,000	122,000	12.0	160,000	132,000	15.0
	U-500	RT	D	175,000	120,000	10.0	195,000	135,000	12.0
		1400	D	125,000	105,000	12.0	140,000	120,000	15.0
	M-252	RT	B	170,000	115,000	15.0	185,000	125,000	20.0
		1000	B	160,000	105,000	15.0	165,000	115,000	22.0

	ALLOY*	TEMPERATURE STRESS	GUARANTEED MINIMUM	TYPICAL VALUES
STRESS RUPTURE	Waspaloy	1350°F.—70,000 psi	70 hours—6% Elongation	130 hours—16% Elongation
	René 41	1350°F.—85,000 psi	30 hours—8% Elongation	60 hours—15% Elongation
	Astroloy	1800°F.—20,000 psi	20 hours—7% Elongation	35 hours—12% Elongation
	Udimet 500	1650°F.—25,000 psi	30 hours—6% Elongation	55 hours—12% Elongation
	M-252	1500°F.—40,000 psi	30 hours—8% Elongation	55 hours—16% Elongation

NOTE: The guaranteed minimums are based upon radial and tangential test locations.

COMPOSITION AND HEAT TREATMENT

	ALLOY*	ELEMENTS C	Cr	Mo	Co	Ti	Al	B	Ni
CHEMISTRY	Waspaloy	.08	19.0	4.3	13.5	3.0	1.4	.004	Balance
	René 41	.08	19.0	10.0	11.0	3.1	1.6	.004	Balance
	Astroloy	.05	15.0	5.0	15.0	3.5	4.3	.030	Balance
	Udimet 500	.07	18.5	5.0	18.3	3.0	3.0	.003	Balance
	M-252	.15	20.0	10.0	10.0	3.0	1.3	.002	Balance

HEAT TREATMENT	A.	1850°F.—4 hours—OQ, 1550°F.—2 hours—AC, 1400°F.—16 hours—AC
	B.	1950°F.—4 hours—AC, 1400°F.—16 hours—AC
	C.	2100°F.—½ hour—AC, 1400°F.—16 hours—AC
	D.	1975°F.—4 hours—AC, 1500°F.—24 hours—AC, 1400°F.—16 hours—AC

NOTE: Refer to appropriate heat treat code in Tensile & Yield Strength table.

*Waspaloy: Pratt & Whitney Aircraft Corp.; René 41, Astroloy and M-252: General Electric Company; Udimet 500: Metals Division, Kelsey-Hayes Company.

contribution to gas turbine progress . . . these new Superalloys with Guaranteed Minimum Properties

permits designing to higher operating stresses . . . increased efficiency . . . greater component reliability for every gas turbine application

Rapid progress in developing the gas turbine has materially extended application of this prime power source to areas other than aircraft. Significant contributions in forging techniques and metallurgical advancements by Wyman-Gordon have in part made this possible.

Now designers are free to explore new frontiers of turbine performance unhampered by former material limitations. The high temperature alloys shown here exhibit outstanding tensile and stress rupture strengths in elevated temperature environments. These alloys have been forged into discs, shafts, rings, blades and vanes on a production scale.

Wyman-Gordon offers these alloys to *guaranteed minimum properties* for such vital components. This is made possible by the broad experience in forging parts from all difficult-to-work materials, including a complete range of low-alloy, high-strength steels; intermediate-temperature alloys; light metals; titanium and the refractory materials.

Our metallurgists and forging engineers are prepared to counsel on turbine components . . . evaluating material requirements and forging of existing designs and development parts. For assistance or additional information on Superalloy forgings, write—Product Manager, Turbine Applications, Wyman-Gordon Company, Worcester, Massachusetts.

WASPALOY

RENE 41

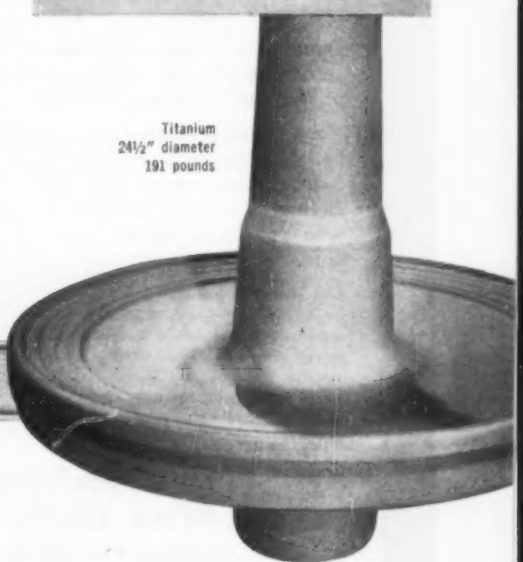
ASTROLOY

UDIMET 500

M-252

MEETING DESIGNERS' NEEDS IN EVERY TURBINE APPLICATION

- Aircraft and Missile
- Nuclear Power and Propulsion
- Rail and Highway Transport
- Power Generation
- Air Supply and Pumping
- Pipeline Boosting
- Auxiliary Service
- Automotive
- Marine Propulsion
- Stationary Power



Titanium
24½" diameter
191 pounds

Titanium
15½" length

EST. 1883

FORGED

WYMAN-GORDON

FORGINGS

of Aluminum Magnesium Steel Titanium . . . and Beryllium Molybdenum Columbium and other uncommon materials

HARVEY ILLINOIS WORCESTER MASSACHUSETTS DETROIT MICHIGAN
GRAFTON MASSACHUSETTS LOS ANGELES CALIFORNIA PALO ALTO CALIFORNIA FORT WORTH TEXAS

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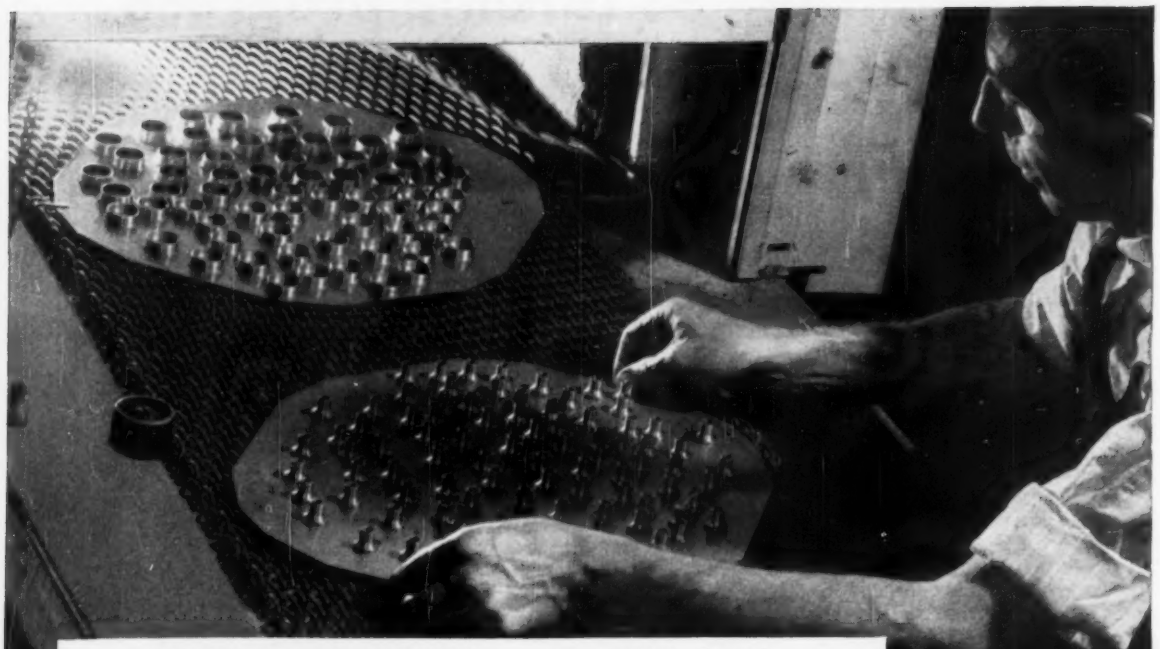


. . . HEAT-PROCESSING - IN THE '60's . . .

CAMBRIDGE METAL-MESH BELTS help you beat *today's* profit squeeze—give you the low-cost production and high product quality needed for the *competitive 60's!* Combined movement and processing speeds up annealing, quenching, washing, sintering, copper brazing, hardening, other operations. You cut labor costs, handling, production time.

Quality is consistent because liquids, gases flow through the belt and around product for thorough treatment.

You save on operating costs, too. Superior belt design and manufacturing techniques mean longer life, fewer repairs. Belts can be made heatproof or acidproof —in any mesh, weave, metal or alloy— with any side or surface attachments.

Call your Cambridge Field Engineer now. He'll be glad to discuss any aspect of Cambridge Belts—from manufacture to installation and service. Look in the yellow pages under "Belting, Mechanical". Or, write for FREE 130-PAGE REFERENCE MANUAL.

The Cambridge Wire Cloth Co.

Department B • Cambridge 1, Md.

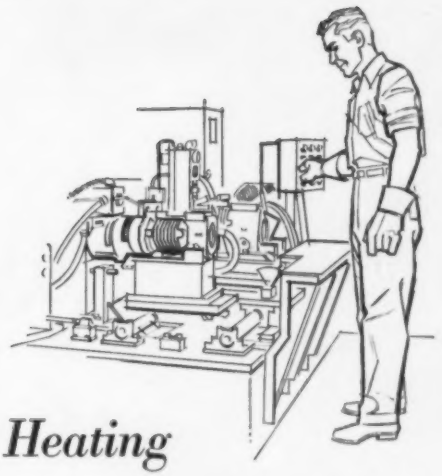
Manufacturers of Wire Cloth, Metal-Mesh Conveyor Belts, Wire Cloth Fabrications

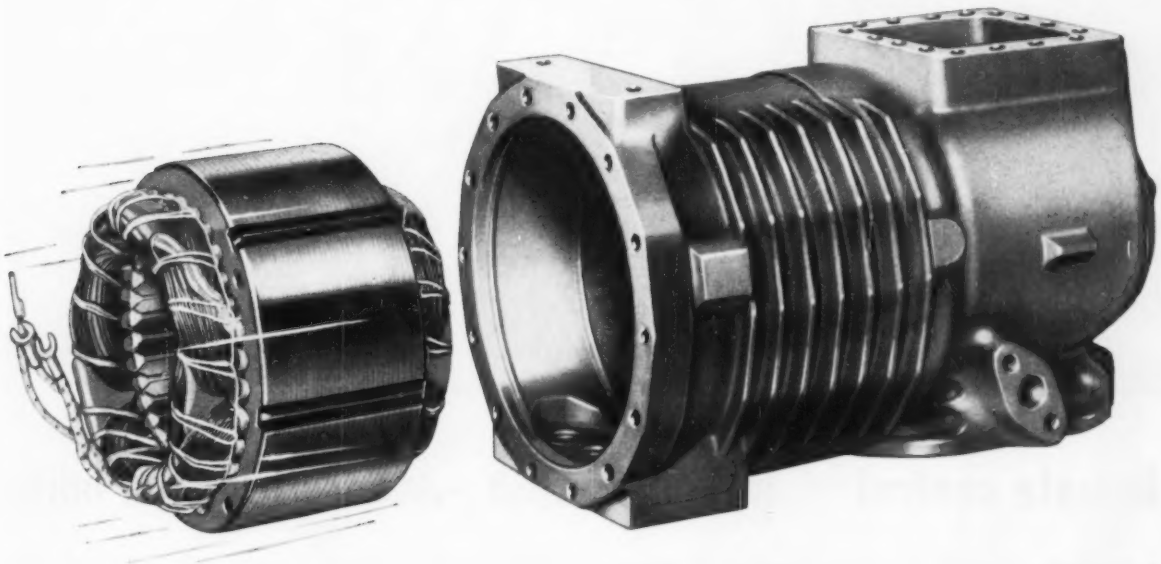
Circle 435 on Page 48-B

How a **Shrink-Fit** E-x-p-a-n-d-s Profits

Copeland Saves $100,000.00 A Year

with TOCCO® *Induction Heating*





Press-Fit Method

In the assembly of motor-compressors for their air conditioning and refrigeration products, Copeland Refrigeration Corporation formerly employed air presses for force-fitting their 1/5 HP through 1½ HP motor housings and stators. This method was costing Copeland $100,000.00 annually in labor, material and quality control expense to maintain the high quality of its product.

TOCCO Shrink-Fit Method

To reduce these costs, Copeland installed a 30 kw, 10,000 cycle TOCCO Induction Heating Unit. Motor housings are heated to 400° F. resulting in up to .013″ expansion. After cooling, the motor housing shrinks to form a predictable and perfect fit with the stator. Stator scoring and distortion are eliminated and $100,000.00 annual saving realized.

Whether your production problem is shrink-fitting or higher temperature applications such as brazing, heat-treating, forging or melting, look to TOCCO for an economical solution to any metal-heating problem.

TOCCO

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Please send copy of "Typical Results of TOCCO Induction Heating—Principles, Applications, Equipment."

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Circle 436 on Page 48-B

At Kaiser Steel Corporation's Fabricating Division, a Model 30 Iriditron is used to spot-check plate welds on the bow section of a steel barge. Light and easily carried, requiring no outside power supply, the Model 30 uses iridium 192. It can take internal and panoramic exposures not possible with standard equipment.

Remote control of iridium...with Budd Iriditron units

- **Especially designed for remote handling of iridium 192**
- **Excellent for panoramic and internal exposure**
- **Permits exposure of iridium sources by remote control as far as 50 ft. away.**

Skid mounted or portable, this Budd Iriditron unit provides all the versatility of the traditional unshielded source for pipe weld radiography, panoramic exposure of multiple specimens, circumferential and longitudinal welds in boilers and pressure vessels. The unit can hold extremely strong sources . . . as much as 30 curies of iridium 192, approximately equivalent to a 260 KV X-Ray machine. This adds up to significant reductions in exposure times.

And you get complete service from Budd—including radioactive source supply and encapsulation, source replacement and disposal, training for your personnel (at no charge) and aid in setting up complete radioactive facilities.

Write or call Budd Instruments Division for our Gamma Radiography Bulletin . . . or for a consultation on your requirements.

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Consult your phone book for sales offices in: Atlanta, Ga., Oak Park, Ill., Dallas, Tex., Los Angeles, Calif.
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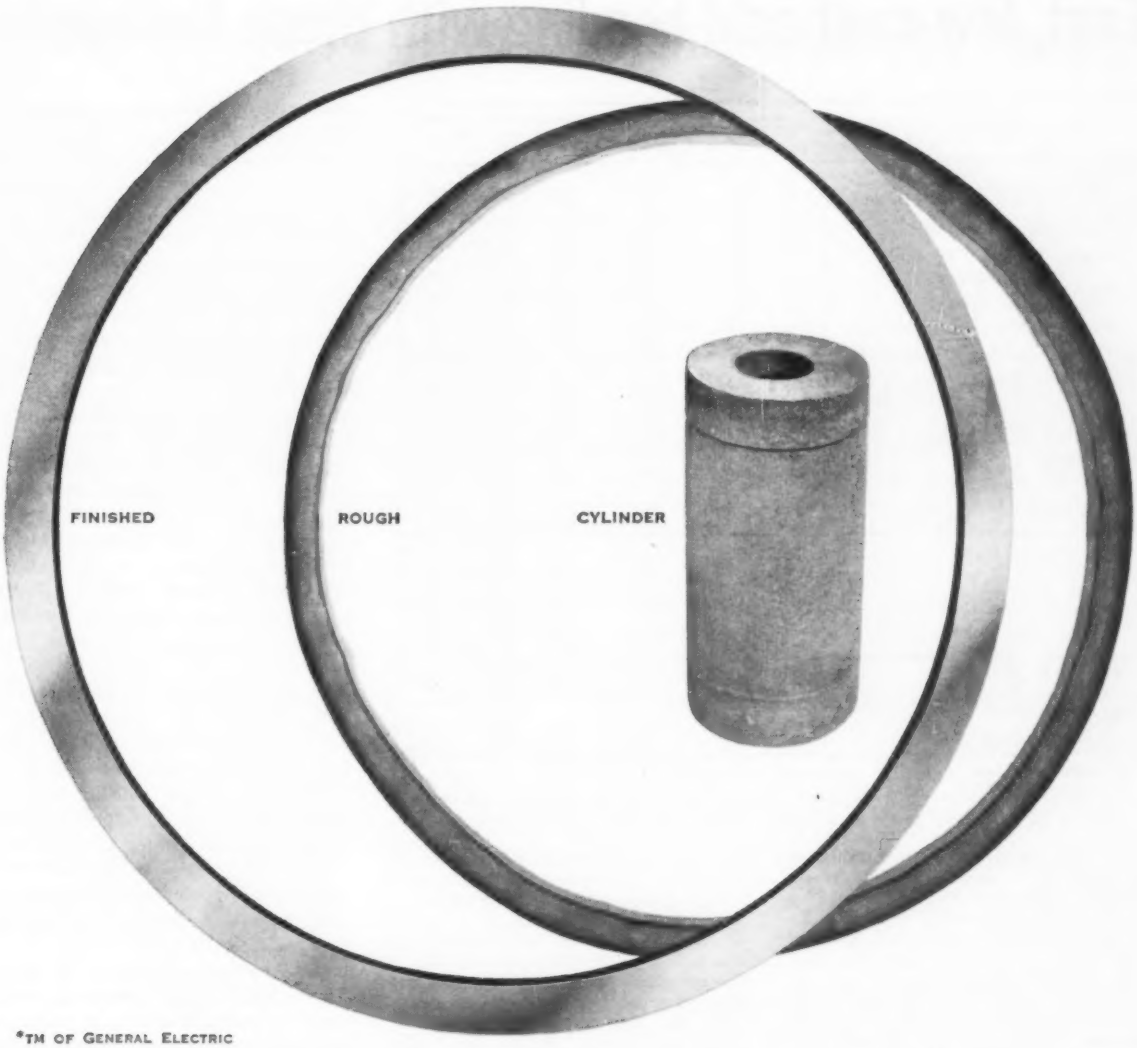
Circle 437 on Page 48-B

NOW—A WELD-FREE RENÉ 41* RING DEVELOPED BY C-M TO ELIMINATE THE PROBLEMS OF WELDED RINGS.

C-M'S RENÉ 41 RING IS FORGED FROM A CYLINDRICAL CASTING INSTEAD OF ROLLED FROM BAR STOCK AND WELDED. THIS INTEGRAL, WELD-FREE RENÉ 41 RING IS THE RESULT OF A CASTING PROCESS DEVELOPED BY C-M USING A THIN CROSS-SECTION RATHER THAN THE CONVENTIONAL THICK INGOT. BECAUSE THE CROSS-SECTION IS THINNER, IT COOLS QUICKER. THIS FAST COOLING PREVENTS SEGREGATION OF ELEMENTS—ELIMINATES STRINGERS. GRAIN SIZE IS MORE UNIFORM, TOO, AND THE RING HAS GREATER HOMOGENEITY THAN RINGS PRODUCED BY OTHER METHODS.



*TM OF GENERAL ELECTRIC

C-M'S PROCESS CAN HELP SOLVE YOUR RING PROBLEMS ON RENÉ 41 AND OTHER DIFFICULT-TO-FORGE IRON, NICKEL AND COBALT ALLOYS. WRITE TODAY FOR COMPLETE INFORMATION.

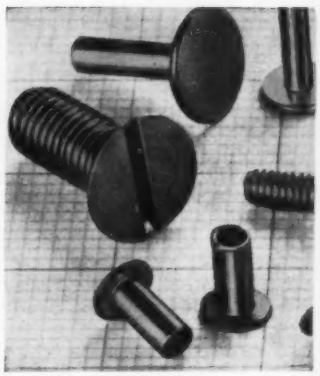
ULTRAMET VACUUM ALLOYS

CANNON-MUSKEGON CORPORATION

METALLURGICAL SPECIALISTS • 2871 LINCOLN STREET • MUSKEGON, MICHIGAN

Circle 438 on Page 48-E

Cold heading is a high-speed, high-volume process even with intricate parts requiring secondary operations. Die sets are not expensive—set-up time is moderate. Scrap is no factor. Cold working improves mechanical properties. Use the handy chart and comparative data covering 14 suitable Anaconda alloys to open the door to some sizable savings. Take a second look at the way you're making parts like those at the right—and connector components in electrical controls—and bases for semiconductor devices.



Fast, low-cost cold heading with these Anaconda

Alloys and Nominal Compositions, %	Temper*	Prop. Limit, 1000 psi	Yield Str., 0.2% Offset, 1000 psi	Tensile Strength, 1000 psi	Red. Area, %	Plasticity Index, %
Brasses						
Commercial Bronze-14	A	20.5	43.0	51.0	83	40
90 Cu, 10 Zn	B	39.0	57.5	64.0	81	61
Red Brass-24	A	23.0	49.5	55.0	82	42
85 Cu, 15 Zn	B	42.0	62.0	71.0	77	59
Low Brass-32	A	33.5	50.0	57.0	81	59
80 Cu, 20 Zn	B	44.0	65.0	76.5	79	58
Cartridge Brass-42	A	32.5	51.0	63.5	80	51
70 Cu, 30 Zn	B	48.0	70.0	82.5	73	58
Yellow Brass-58	A	38.0	52.0	62.0	79	61
65 Cu, 35 Zn	B	52.5	70.5	81.0	72	65
Cupro Nickels						
Cupro Nickel, 10%-755	A	38.5	52.0	54.0	81	71
88.35 Cu, 10 Ni, 1.25 Fe, 0.4 Mn	B	56.5	76.5	79.0	80	72
Cupro Nickel, 20%-712	A	34.5	57.5	60.5	83	57
79.5 Cu, 20 Ni, 0.5 Mn	B	46.0	69.5	74.0	74	62
Nickel Silvers						
Nickel Silver, 18%-716	A	37.5	57.5	60.0	83	62
72 Cu, 9.75 Zn, 18 Ni, 0.25 Mn	B	39.5	64.5	67.5	78	59
Nickel Silver, 12%-744	A	43.0	58.0	67.0	77	64
65 Cu, 22.75 Zn, 12 Ni, 0.25 Mn	B	50.5	81.0	86.0	73	59
Tin Bronzes						
Phosphor Bronze, (A)-351	A	38.0	60.5	66.0	83	58
94.75 Cu, 5 Sn, 0.25 P	B	50.0	80.0	87.5	79	57
Phosphor Bronze, (C)-353	A	44.0	64.0	76.5	81	58
91.75 Cu, 8 Sn, 0.25 P	B	57.0	90.0	99.0	76	58
Phosphor Bronze, (D)-354	A	49.5	73.5	86.0	71	58
89.75 Cu, 10 Sn, 0.25 P	B	66.5	101.0	111.0	69	60
Leaded Copper-126	A	20.0	40.0	41.5	69	48
99 Cu, 1 Pb	B	27.5	48.0	51.5	64	53
Copper-Silicon Alloy						
Everdur®-1015	A	34.5	54.0	55.5	81	62
98.25 Cu, 1.5 Si, 0.25 Mn	B	43.5	67.0	74.0	76	59

The temper designations "A" and "B" have no commercial significance.

This table includes results of special tension tests made in Anaconda laboratories. It is a useful guide to the right copper alloy for a cold heading job.

Each alloy is shown in two standard tempers, A (¼ hard) and B (½ hard). These designations show the amount of mechanical strengthening the alloy has been subjected to before cold heading. Though it is assumed that the cold heading process enhances these values, the preheading values are widely used in design—to be on the conservative side. The tempers obtained by wire drawing represent the following cold reductions: A, about 20%; B, just under 40%.

"Plasticity Index" is a useful indicator of the amount of cold work an alloy will take. It is the ratio of proportional limit to ultimate tensile strength expressed in per cent. A low value of the index indicates that a large part of the total stress range to fracture is devoted to deforming the alloy plastically. Thus an alloy with a low value flows more easily during the cold heading, and parts made from it can be designed with greater complexity of shape. For best formability, a low plasticity index should be coupled with a high percentage reduction in area—to minimize shear fracture.

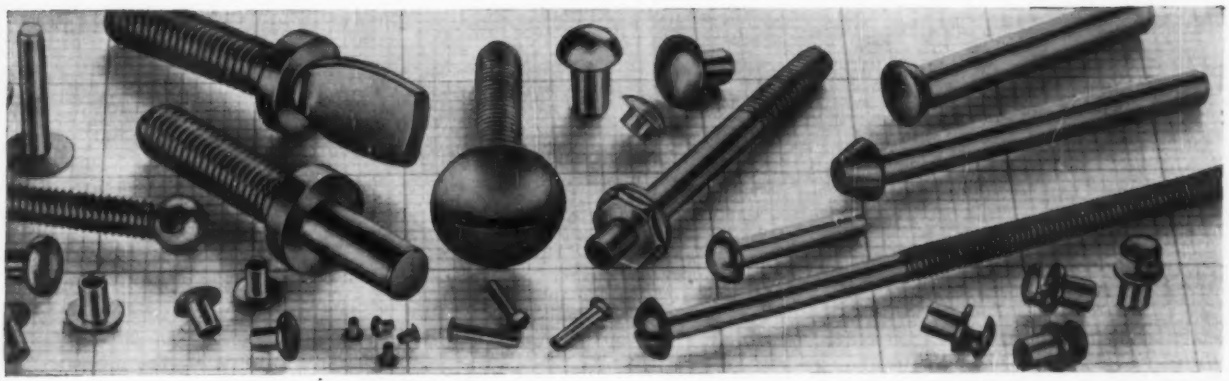
The effect of alloying elements on mechanical properties is clearly seen in the table. The main purpose of alloying copper is to increase ultimate and yield strengths. Alloying has other important effects, but the table shows how these alloying elements influence the balance between increased strength and formability in cold heading. In the selection of an alloy for cold heading, this interplay is usually the major consideration—with factors like corrosion resistance, color, surface finish, and cost playing suppiementary roles.

WHAT ALLOYING ELEMENTS DO—Addition of a second element, or a series of elements, to copper affects the crystal structure so that flow in certain directions becomes difficult except by going to higher stress levels. The effect depends not only on the element added but on its proportion in the matrix. Here are brief descriptions of how the various major alloying elements influence the engineering behavior of copper metal:

ZINC plus copper makes brass up to 20%, the "low brasses"; from 20% to about 35%, the "high brasses." The addition of zinc substantially improves strength, yet the metal retains good formability (a low plasticity index with high reduction in area). Malleability does, however, decrease as the percentage of zinc increases. The diagram on the next page illustrates how a choice is made between alloys of similar zinc content. Thermal and electrical conductivity decrease as zinc content increases, and color changes from reddish hue to greenish yellow.

NICKEL, the principal alloying element in the cupro nickels, improves resistance to corrosion. In the nickel silvers, nickel and zinc also control color. As nickel content increases, color moves from brass shades to silver white. Both cupro nickels and nickel silvers have high percentage reduction in area. Their slightly higher plasticity index tends to reserve their use to parts requiring exceptional corrosion resistance.

TIN as the main alloying element in the phosphor bronzes contributes high tensile and yield strengths, along with excellent fatigue resistance. For cold heading, the biggest advantage of phosphor bronzes is their favorable combination of low plasticity index and



alloys can solve more problems than you realize

high reduction in area—second only to the straight brasses. Electrical and thermal conductivities drop as tin content increases.

LEAD enhances the machinability of copper by acting as an embrittling agent, correspondingly reducing the per cent reduction in area, but with little effect on the plasticity index. For cold heading, this means that even though the plastic range is great, there is a limiting amount of work hardening that can be reconciled with shear strength. Though it is not recommended for shapes where shear forces predominate in the cold heading operation, Leaded Copper-126 has some very interesting advantages. It has an electrical conductivity rating of 98% IACS and a machinability rating of 80 (free-cutting brass = 100) for economical secondary operations. It offers a possible means of reducing the cost of electrical connector components, where shape and tolerances are within the range of cold heading capabilities.

SILICON content of 1.5% adds toughness to copper and improves its ductility — providing a combination of plasticity index and reduction in area favorable to cold heading. Such an alloy is well-suited to impact applications, particularly where very low temperatures are met, as in cryogenic equipment. As the lower copper-silicon alloys work-harden less rapidly than those of higher silicon content, Everdur-1015 (shown in the table) was developed for cold headed parts, especially where secondary operations, like roll-forming of threads, are required.

UPSET RATIO IS IMPORTANT — The alloys and alloy groups shown in the table are all suitable for cold heading. Often, however, the precise strength level or the exact service conditions are not known. Then the best guide is the approximate amount of cold work needed to form a given upset. This is the upset ratio—the ratio of final upset diameter to the original wire diameter.

WHEN UPSET RATIO IS FROM 2 TO 3, only one or two blows are usually necessary, and the choice of material is not critical. Any alloy from the table, in any temper, will be suitable.

WHEN UPSET RATIO APPROACHES 4.5 TO 5, two or more blows are necessary, and selection of material becomes critical. Choice is usually made after trial heading of one or more possible combinations of alloy and temper.

FOR UPSET RATIO OVER 5, multiblow or progressive heading must be employed, and annealing between blows may be necessary. Here only alloys with the most favorable combination of plasticity index and per cent reduction in area should be considered.

SEMICONDUCTOR BASES. As quantities of these components soar, cold heading should be considered for economical production. Many of the copper alloys offer the high electrical and thermal conductivities needed. But severe heat cycling in manufacture rules out the cold heading alloys listed. The metal must be deoxidized or oxygen-free to resist hydrogen embrittlement. For secondary operations, it must also have good machinability. And where high torque is used to tighten the base to the heat sink, it must in addition have high strength. Various combinations of these properties are found in such alloys as DLP Copper-104, OFHC* Copper-120, Tellurium Copper-127, and Chromium Copper-999 — all available as cold heading wire.

TECHNICAL SERVICE. Although Anaconda American Brass does not produce cold headed parts, it does make cold heading wire in the wide variety of alloys and tempers required. Anaconda has specialists in this field to help you select the right material for your job. Simply give us a sample, sketch, or description of the part or parts—along with service conditions, quantities, properties required — for a recommendation. See your Anaconda representative, or write: Anaconda American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

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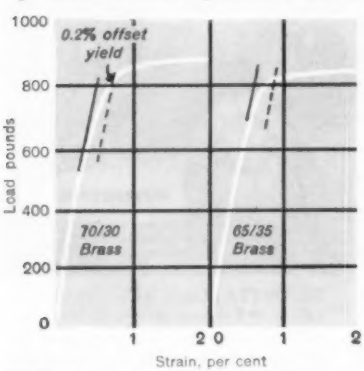
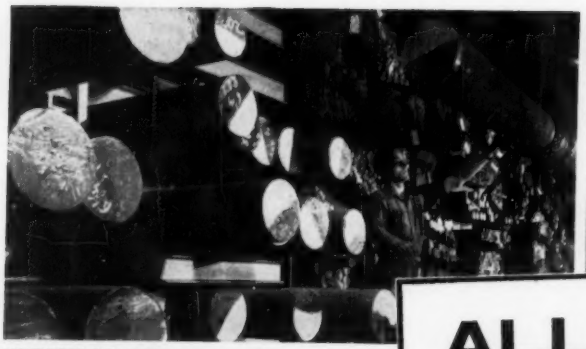


Which is more ductile—70/30 brass or 65/35 brass? These load-strain curves on the two alloys in temper A (¼ hard, 18% reduction) shows 70/30 cartridge brass is slightly more formable—because it begins to flow plastically sooner than the 65/35, yet continues to deform to a higher ultimate load. Thus the plasticity index is lower. This, combined with higher per cent reduction in area, makes 70/30 a better choice when shear is a major factor.

ANACONDA®

COPPER AND COPPER ALLOY COLD HEADING WIRE

Anaconda American Brass Company



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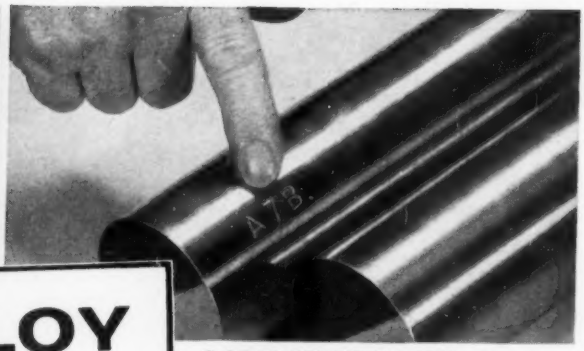

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	E8615
	8620
	8620 leaded
	E9310
	Nitralloy 135 modified
Heat-Treated Medium Carbon	4140
	4140 TG & P
	4140 leaded
	4147/50 leaded
	4340
	Rycrome®
	Rycrome TG & P
	Nikrome®
	Nitralloy
Medium Carbon Annealed Direct Hardening	4140
	4140 leaded
	4147
	4147/50 leaded
	4340
	E6150
	8647 leaded
Rycut Free Machining	Rycut® 20
	Rycut 40 and 50 annealed
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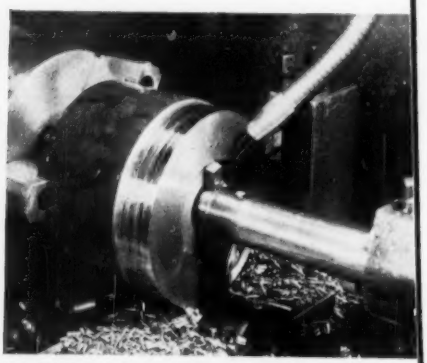
	Rycut Heat-Treated

PLATES

8620	T-1
E8615	Aircraft Quality
4140	4130 & E4130



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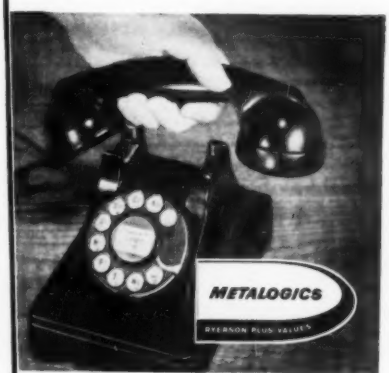
DEPENDABLE DELIVERY—Big-capacity facilities and an experienced staff with a service attitude assure quick delivery of any quantity—within hours if needed.



BE "METALOGICAL"—All the plus values of Ryerson service on alloy steel add up to the Ryerson science of giving you "optimum value for every purchasing dollar." So be "Metalogical"—call Ryerson.

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Circle 440 on Page 48-B

Metal Progress
International and Forecast Issue
Vol. 79, No. 1 January 1961

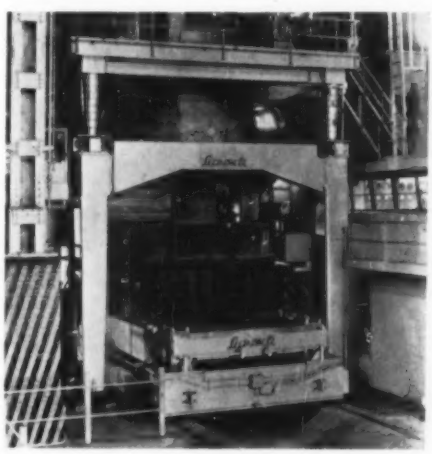
Technical NEWS in Brief

German Degassing Process Unveiled

One year ago *Metal Progress* (January 1960, p. 116) revealed that Crucible Steel Co. was planning to install a 40 to 200-ton Dortmund-Hörder degassing unit. Now comes the information that the unit has been built, and is being readied for production. The unit (see photo) is essentially a bottle which is open at the bottom. In operation, a ladle of molten steel is moved under the vacuum chamber which is then lowered so that the end of an open tube is below the slag layer. When the pumping system is turned on, it reduces the pressure in the chamber to about 1 mm. and atmospheric pressure causes liquid steel to rise about 60 in. above its original level in the ladle. The vacuum unit is then lowered further and the molten steel spills into the chamber to expose a tremendous surface area of steel droplets to vacuum. Because of their higher internal pressure, hydrogen, oxygen, and nitrogen gases leave the molten steel.

When the unit is raised, the steel which has been degassed flows back into the ladle. Inertia of the steel causes it to sink to the bottom of the ladle, thus raising untreated steel into the unit where the cycle is repeated. The unit is raised and lowered until the entire heat has been degassed; this takes about 30 min. for a 170-ton heat. An advantage in this technique is that alloy additions (such as aluminum for control of grain size) can be made from inside the unit late in the degassing cycle. Most of the oxygen is gone by then so there is little danger of oxide inclusions being formed.

Engineers at Crucible foresee a number of other benefits of the unit. For one thing, the long soak currently used to eliminate hydrogen will be unnecessary. This should reduce the length of time from melt to delivery. Also, the removal of oxygen should result in cleaner steels than can be obtained by air melting. Better transverse ductility, greater resistance to fatigue and higher impact



Dortmund-Hörder Degassing Unit
Hydrogen, Oxygen and Nitrogen Are Removed From 200-Ton Heats

resistance can be expected so that steels degassed by this method should prove satisfactory for turbine rotors, bearings, die casting dies and aircraft and missile applications.

Welded Titanium Coils Heat Acid Solution

Typical of the progress being made by the titanium industry is the application of the corrosion resistant metal in heat exchangers in chemical processing. An example of the inroads being made is the 45 heat exchanger coils being fabricated for two pigment plants by Saffran Engineering Co., East St. Clair Shores, Mich. Titanium was chosen for the coils on the basis of excellent corrosion resistance, good heat-transfer characteristics and the potential for annual operating economies of $50,000.

The coils carry steam used to heat tanks of sulphuric acid (25 to 30%) to as high as 210° F. Previously most of the difficulty in this process came from build-up of corrosion products on the coils, thus resulting in a gradual increase in the amount of steam needed to heat the acid. With titanium coils, however, steam requirements have been cut 75% since the metal sheds the sulphate scale (when the tank is boiled out) after it builds up to a depth of about 1/64 in. Additional economies are achieved by the long life of the titanium coils which should last well over ten years. This compares to the nine-month life of previously used coils.

Units for the heat exchangers – each a coil with ten convolutions (see photo) – were fabricated from welded titanium tubing (2 in. O.D.) because the pressures in service did not require the more expensive seamless variety.

Since tubing is shipped in 18-ft. lengths, seven welded joints were required per coil to obtain the 120 linear ft. required. All 18 lengths of tubing are joined before the coil is formed.

Coils are fabricated in about 65 man-hours using a heliarc welding gun modified by the addition of a simple cannister packed with copper turnings (shredded from a cleaning pad sold in supermarkets) and taped around the head of the welding gun. Argon, fed into the cannister, is diffused over the weld zone by the turnings. The gas is also used to protect the underside of the weld, being concentrated at the heat-affected zone by a series of gaskets and a bronze diffuser.

In welding the 18-ft. lengths together, Saffran first tack welds two sections into position. A cannister is then placed around the joint to serve as a welding chamber. After the coil is formed, spacers are welded in place using argon shielding. The gas is fed directly into the coil and through a small hole drilled in the spacer.

TITANIUM COILS FOR HEAT EXCHANGERS
Improved Efficiency and Long Life
Result in Operating Economies

High-Temperature Alloys Used for Tooling

Some of the alloys normally considered only for high-temperature applications have been found to be better in certain kinds of tooling than any of the conventional tool steels. In one instance mandrels of toolsteel which were used in the hot extrusion of beryllium copper lasted no more than five "pushes" before failure. Metallurgists at Carpenter Steel Co., Reading, Pa., report that when the mandrel was made instead from Waspaloy, a familiar high-temperature alloy, it lasted for 22 pushes without excessive deterioration. Another exaample: When an extrusion die used in hot forming of beryllium nickel was made from A-286, it outlasted any other dies previously tried.

Intermetallic Compound Shows Unusual Magnetic Behavior

Fundamental studies of magnetism have resulted in the discovery of unusual properties of chromium manganese antimonide. The intermetallic compound is the first known to exhibit transition from magnetic to nonmagnetic nature at temperatures governed by its composition. The transition temperature can be varied from near absolute zero to over 210° F. by changing the proportion of chromium. Scientists who discovered the behavior of the compound at DuPont's Central Research Department in Wilmington, Del., state that the change occurs without hysteresis. Maximum magnetization is achieved just above transition and as in other ferromagnetic materials, it drops off as temperature increases.

Changes in West Germany Strengthen Its Industry

Two major circumstances will affect the metallurgical climate in West Germany in the near future and will have corresponding influence on the situation in America and in other manufacturing sections.

First is the emergence of powerful groups of companies, like Krupp's and Rheinische Stahlwerke, integrated associations including blast furnace and steel plants, foundries and machine shops, whose output is heavy equipment ranging from ships to railroad cars, rolling mills to hydraulic pumps. Each of these groups has central staffs for engineering, for research, and for sales – truly a potent competitive unit.

Second is a new source of power – gas and oil wells in Europe and North Africa and fleets of tankers bringing petroleum from overseas. As late as 1957 everyone was worrying about the high cost of fuel (coal could be shipped from West Virginia and sold competitively in the Ruhr) and wondering whether atomic reactors generating power could come to the rescue. Now it appears that heat from gas and oil can produce electricity so cheaply that a large expansion in the production of aluminum and magnesium can be expected, these metals and their alloys in turn becoming active competitors to the age-old irons and steels in dozens of important applications.

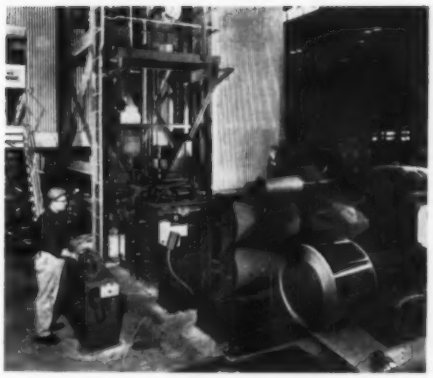
Large Oxygen Unit Serves Openhearth Furnaces

With the addition of a new oxygen plant which can provide a source of 12,000,000 cu.ft. of oxygen per day, Great Lakes Steel Corp., Ecorse, Mich., becomes the latest entry into the ranks of steelmakers which make widespread use of oxygen. Over 70% of the oxygen produced in the unit (built by Linde Co., Div. of Union Carbide Corp.) will go to 15 openhearths; the excess is used for scarfing, scrap preparation, burning and welding.

Great Lakes intends to expand its oxygen steelmaking capacity by adding two basic oxygen converters, each of which will produce at a rate of 200 to 250 tons per hr. Construction is expected to begin sometime this year. To supply these new units, another 500-ton-per day oxygen plant will probably be necessary.

Quality Competition Leads to Improved Stainless Strip

Competition in decorative trim for the auto industry has brought advances in stainless steel technology. With plated steel and aluminum vying for the lucrative auto market, stainless steel producers have been pressed into programs to iron out the problem of corrosion of stainless trim, the source of irritation on the part of some of the big users, primarily the auto makers. The difficulty seems to be narrowed down to depletion of chromium on the surface of stainless strip as it is annealed and pickled. This, of course, lowers its corrosion resistance. Only in recent months has the answer come – new bright annealing furnaces which have the capacity to handle large quantities of strip.



VERTICAL FURNACE ANNEALS STAINLESS STEEL
Continuous Strip Is Heated in Dry Hydrogen

First of the high-capacity bright annealing furnaces went into service during the past few months at Wallingford Steel Co., Wallingford, Conn., and at Allegheny-Ludlum's West Leechburg, Pa., Works. Built by General Electric Co., the furnaces stand some 100 ft. high. The usual metal muffle has been replaced by high-purity alumina. Strip up to 27 in. wide is heated electrically in an atmosphere of hydrogen (dew point −65 to −75° F.). The technical achievement here amounts to the production of stainless strip that retains its corrosion resistance and in such quantities that users can count on good supplies at the same price as conventional annealed and pickled strip. In addition, the mirror finish which results means less buffing will be required after parts are formed.

New Alloy for Steam Power Plants

To improve thermal efficiency, several large power stations here and abroad have been built to operate with steam at about 1100° F. and 2350 psi. Under these conditions Type 316 stainless steel (17-12-2.5 Cr-Ni-Mo) has been used in the main system of some recent plants in an attempt to avoid the trouble which had cropped up with cracked welds in the Type 347 alloy originally used. Some of the plants have replaced the offending items with 2.25 Cr, 0.5 Mo steel.

Going on the assumption that most of these defects in weld deposits and heat-affected zones are variations of "hot cracks", Westinghouse research men have discovered that, of all the common alloying elements and impurities, manganese and molybdenum when properly balanced are particularly beneficial in austenitic stainless steels. They therefore have devised a new alloy called "Kromarc-55", with a typical analysis of 0.04 C, 16 Cr, 20 Ni, 9.5 Mn, 2.25 Mo and 0.3 Si and the common impuri-

ties held as low as possible. It is fully austenitic, resists hot tearing when cast, and is not susceptible to hot cracks at and alongside joints. Mechanical properties at high temperature are similar to those of Type 316 stainless.

The alloy is already scheduled for use as cast nozzle chambers and as the welding electrode for fabricating high-temperature, high-pressure steam turbines. Frederick C. Hull, who is responsible for the alloy, believes that this analysis will be a basis for weldable steels of higher strength for high-temperature service.

Trends in Engineering Education in Canada

The Engineering Institute of Canada has recently estimated the number of engineers who will graduate from its universities and colleges in the spring of 1961 – namely 2651, an increase of 410 from the 1960 total. Metallurgical graduates will not increase in number to the same degree – 62 in 1961 or 2.35% of the total, versus 57 in 1960 or 2.54%. (There are 12 times as many civil engineers graduating as metallurgists.) The proportion of metallurgists to the whole is about the same in Canada as in the United States – a tiny 2.25 to 2.5%.

Progress in Nonmetallic Materials

Titanium diboride is being fabricated into shapes with properties that suggest potential uses in applications requiring either strength at high temperatures, high hardness, inertness in molten nonferrous metals, or low electrical resistivity.

Produced by National Carbon Co., Div. of Union Carbide, New York, the refractory compound is made by reducing oxides of titanium and boron. The process gives a fine, high-purity powder which can be fabricated into various shapes. Cylinders 14 in. in diameter, 20 in. long and weighing 260 lb. have been made.

One of the significant characteristics of titanium boride is that it maintains a flexural strength of 35,000 psi. up to 3630° F. Weight is about half that of stainless steel. These properties open the possibility of using titanium boride as ball and roller bearings exposed to high temperatures. High hardness of the compound (3300 kg. per sq. mm., Knoop) will also make it useful in working with hard metals, either in the form of cutting tools for machining or as balls, cylinders or granular abrasives used in finishing. It may also be employed where abrasion resistant surfaces are needed.

Although not resistant to molten ferrous metals, titanium boride is inert to molten aluminum, zinc and slags. This property suggests uses in melting and casting of the nonferrous metals – spouts, furnace linings, funnels. Low resistivity (20 to 30 micro-ohm cm. at 70° F.) has prompted several producers of aluminum to consider it for lead-in connections in cells which produce aluminum. Primary advantage here is that power losses through the pot lining are reduced by as much as 30 to 50%.

Shapes Formed From Titanium Boride Powder
New Process Yields Hard, Refractory Parts

From Here and There

From Canada comes the news that a ladle which will carry 500 tons of molten steel has been constructed. Built by Marine Industries Ltd., Sorel, Que., the ladle weighs 82 tons. It has a 3-in. thick bottom and its sides are reinforced with ribs made from plate 12 in. thick.

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Satin finishes on electroplated nickel are being produced during plating in a new process now in the pilot-plant stage. Announced by Udylite Corp., Detroit, the nonreflecting nickel is expected to find use in metal furniture, auto trim, camera components and builders and marine hardware.

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Six aluminum extrusions, each 82 ft. long and 25 in. wide and joined mechanically, make up the sides of an 85-ft. long aluminum railroad car now being tested. Built by Harvey Aluminum, Torrance, Calif., the car is a prototype unit designed for long loads weighing up to 134,100 lb. The gondola is covered by four 20-ft. panel extrusions which can be removed.

Better Quality Through Nondestructive Testing

If you are looking for consistent levels of quality in the products your company is making, you will be interested in a series of articles on nondestructive testing which will appear in forthcoming issues of *Metal Progress*. Based on a comprehensive in-plant symposium at Westinghouse Electric Corp., this series of eight reports begins next month with "Why Nondestructive Testing Is Needed", by Robert C. McMaster, editor of the Nondestructive Testing Handbook. This article includes information on the application of nondestructive testing from both production and economical standpoints. As an added feature many of the various types of defects which can be located by such tests will also be illustrated.

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TECHNOLOGY FORECAST '61

Problems and Prospects in Metals and Metalworking

Rising costs are causing furrowed brows among men in metalworking management. A steady upward creep in the cost of materials and labor, in the face of a strongly competitive economy, is showing up in declining profit margins. A case in point comes from W. G. Scholl, executive vice president of Allis-Chalmers Mfg. Co. Speaking before the Farm Equipment Institute in Dallas last September, he stated that tractor prices have risen 45.7% since the 1947-1949 period while materials used in the tractors have gone up 69.5% and the cost of labor has climbed 120%.

This situation—common to most metalworking plants—is stirring technology consciousness at all levels of management as a means to offset rising costs through improved efficiency of production operations. Aside from problems of everyday manufacturing, a technological storm is boiling up in new industries—satellites, missiles, hot aircraft, electronics and atomics. As we progress into the 1960's, many companies will be reoriented from traditional industrial and consumer goods to the products of more advanced technologies which will provide new sectors of growth for them.

The Challenge of the Materials Age

The era is referred to by some as "The Materials Age"—an age in which most advanced mechanisms owe their existence to new materials. Equally important—new materials, yet to come, promise almost unbelievable breakthroughs in compactness, space exploration, communication and the utilization of energy.

The Department of Defense says that over the next few years it will be spending on the order of $100 million per year in sponsored programs in materials research. The prediction is that over 90% of the objectives sought (many of the ideas are in today's dream area) will be realized. Materials born of the new technologies will find important uses in conventional manufacturing—a ceramic coating developed for a nose cone will improve diesel engine performance when applied to an aluminum piston head . . . a filter

fabricated from stainless honeycomb will solve problems in the process industries.

It is not only in the fields of advanced technology that materials are the key to progress. In almost every area of manufacturing they are becoming the foundation in designing, engineering and planning products.

Space Alloys: Many New Levels

During the 1960's it is expected that our Government will spend from $30 to $50 billion on space exploration for all purposes, civilian and military. While all the glowing predictions being made for space will not be here tomorrow or the next day, it seems more important that we recognize the significance of the period and what it means to technology. However we think of it, this is a dawning era which in its scope and potential promises to dwarf much of what has gone before.

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For one thing, space technology is requiring new definitions for "high-temperature" and "low-temperature" metals because conditions encountered are ranging to greater and greater extremes. Engineers who design rockets and spacecraft must deal with temperatures of 5000° F., and it appears likely that the advent of propellants with higher energy will extend requirements to 8000° F. and beyond.

Superalloys: Mainstay for High Temperature

Nickel and cobalt superalloys will be called upon to furnish most of the heat resistant materials for the space age at least for the near future. It appears that all but certain "hot spots" may be within their capabilities. The operating limits of nickel and cobalt-base alloys have been expanded in the past few years by the development of over a dozen new compositions. Some of these new alloys can be rolled into sheets; others are suited for precision casting. Recent efforts in nickel-base alloys have achieved a material for use at 1900° F. for a 100-hr. rupture life at a stress of 15,000 psi.

If you examine the composition of the new nickel-base alloys, such as René 41 and Astroloy, you will find they have much in common. They all consist basically of a nickel-chromium solid solution with various amounts of tungsten, molybdenum and columbium added. These additives strengthen the matrix solid solution and also participate in carbide formation. Nearly all of the new nickel-base alloys also contain appreciable amounts of cobalt, which increases creep strength. Precipitation hardening is brought about by aluminum and titanium additions. Boron and zirconium, added to several more recent alloys, improve high-temperature strength and ductility.

The new cobalt-base superalloys contain 19 to 25% chromium, which with carbon gives a high-strength material that is hardened by carbide precipitation. Nickel is usually included in the alloys, as is at least one of the refractory carbide-forming elements, such as tungsten, molybdenum, tantalum and columbium in various amounts.

Basis for Improved High-Temperature Alloys

Many researchers working on the nickel-base superalloys believe that the most opportunity for significant improvements depends on utilizing the powder metallurgy technique, followed by extrusion, to introduce a stable dispersed phase into a strong alloyed matrix. Significant progress is being made in nickel-base alloys having a relatively stable dispersed phase (such as Al_2O_3) but strengths are not yet equal to the best nickel superalloys. Progress would be faster if high-purity alloy powders of very fine particle size (less than 0.1 micron) were available and if techniques for handling such powders without contamination were common.

For operation above 1900° F. with stresses greater than about 15,000 psi., refractory metals will probably be required. Their need is almost a certainty at 2200° F. and above, regardless of stress levels. The interest in refractory metals a few years ago was for advanced propulsion devices in aircraft. Now they are required in the nozzles of solid-propellant rockets and are essential in re-entry vehicles and space power systems.

As a result of increased research, several new high-strength refractory metal alloys are just now emerging from the laboratory. Because some applications, such as re-entry vehicles, require only short exposure to the environment, coatings have been developed which appear satisfactory to protect against oxidation. The period ahead should see increased optimism in applying refractory metals in certain applications. But a look to the future indicates that only relatively small quantities will be used in these specialized areas. Due to the great cost of research and development and because the refractory metals are essential to meet goals that cannot be realized otherwise, it appears that the government must aid in the financing.

A major venture in this direction is the sheet rolling program sponsored by the Navy Bureau of Weapons. Substantial progress was made last year. Both the powder and arc melting processes are under study and all four refractory metals are included. The objective is to develop processing techniques for sheets, 18 to 36 in. wide, with close tolerances on thickness and flatness. It is expected that by the end of this year large sheets of columbium and molybdenum will have been produced; tantalum alloys and tungsten should follow a little later.

Metals for the Supersonic Transport

Plans for a 2000-mph. commercial jet transport, the next thing to a passenger-carrying missile, will get underway in 1961. Some of the construction problems for this craft are being solved in the Air Force B-70 program which has already required 5,000,000 engineering man-hours of development work and ultimately will involve about 8000 suppliers throughout the nation. But a thorough development program will still be needed. Steels, high-temperature alloys and titanium will be used as constructional materials and will be subjected to a complex program of creep cycling, thermal stress cycling, stress-corrosion and mechanical fatigue.

Perhaps even more important is that concepts of toughness, notch ductility and tear resistance must be investigated for new classes of materials under new stress conditions at the unexplored intermediate temperature levels which the aircraft will encounter (about 500° F.). Certainly, a formidable task lies ahead in this area.

Metals at Low Temperatures

Demands on metals to meet requirements at the low end of the thermometer scale are fully as severe as those at high temperatures. Hydrogen, the most promising of present chemical fuels, boils at −423° F. Liquid oxygen and fluorine, two important oxidizers, boil at −297 and −350° F., respectively. Furthermore, the environment in which rockets will be operating —space itself—approach absolute zero.

Most recently aluminum, titanium and the nickel steels have received wide attention. In the range −200 to −420° F., many wrought aluminum alloys (strain hardening types such as 5456, 5356, 5083 and 5154) exhibit an increase in strength and ductility. Greater use of these alloys at cryo-

genic temperatures can be expected because excellent mechanical properties are preserved in the welded zones.

The titanium alloy containing 5% aluminum and 2.5% tin is most promising for tanks designed to handle liquid hydrogen. It has displayed excellent ductility (about 11% at −423° F.) and good impact properties. Low-temperature pressure vessels fabricated of titanium alloyed with 6% aluminum and 4% vanadium, originally specified for the Atlas, are now used in liquid-fueled vehicles such as the Titan, X-15, Agena and Ablestar.

Nickel steels also have been in the running in the growing market for cryogenic vessels. However, since the aluminum alloys don't need heat treatment (either for strengthening or stress-relieving), they have the advantage in final cost. This situation may change. For example recent tests at −320° F. on large vessels of welded 9% nickel steel, quenched and tempered (rather than double normalized and tempered, as recommended in A.S.T.M. Specification A-353), show that stress-relieving, although required by code, is not really necessary. In fact, it may be slightly detrimental.

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We need to know more about how metals behave at cryogenic temperatures. The effect of long-time exposure and applied strain at these regions remains almost entirely unexplored. Strain-induced and time-dependent metallurgical reactions may occur, particularly in thin tanks carrying liquid hydrogen. In addition, the general tendency of increased notch sensitivity at −423° F. over that at slightly warmer temperatures should be given more basic study.

Shaping Space Age Metals

Because some of the metals and alloys systems most useful to the aerospace industry bring with them problems in metalworking, much effort has been directed toward new forming and fabricating methods such as chemical milling, electroshaping and explosive forming.

Efforts to improve machining techniques for the difficult alloys will be based mainly on more powerful and rigid machine tools with automatic controls and on the development of more durable cutting tools. Cutting methods will also be supplemented more and more by chipless techniques, such as forming by heavy pressure and impact.

Explosive forming, for example, is gradually emerging as a true production tool. As a manufacturing technique it is not expected to replace conventional equipment; if a part can be formed satisfactorily by ordinary methods, generally it is more economical to do so. Exceptions to look for are extremely large parts and those with unusual contours and close tolerances. Spring back is no problem; parts are produced consistently to within 0.001 to 0.002 in. of the die. Hot explosive forming using sand as the transmitting medium is used for titanium, magnesium and other difficult-to-form parts.

Forming problems and the limitations placed on certain desirable metals by notch sensitivity, low fatigue-to-tensile-strength ratio, hydrogen embrittlement and the phenomenon of delayed cracking have prompted engineers to take a close look at nonmetallics. It may well be, for example, that plastic reinforced with fiberglass will become an important material for solid-propellant rocket motor cases because of its favorable combination of strength and low density. This material has been adopted for the motor case of third stage of the Minuteman. It has been estimated that steels with yield strengths in the vicinity of 400,000 psi. are needed if metals are to remain competitive in this area. But the picture is not without hope to metallurgists. Techniques such as "ausforming" promise new strength levels for steels. Recent experiments on ausformed alloy steel have achieved a yield strength approaching 390,000 psi. with 25 to 40% deformation.

Tooling problems encountered in forging some of the superalloys have

increased the demand for better hot work die steels. Substantial improvements are being made in the conventional 5% chromium hot work steels by the addition of vanadium carbide to improve wear resistance without undue sacrifice of toughness. Another approach is the use of some of the superalloys themselves for various types of hot work dies.

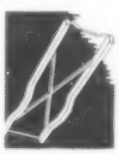
Nuclear Industry Searches for Economy

Now concentrated primarily with the military, the future of the nuclear industry will depend on its ability to compete with fossil fuels, a task which can only be aided by better materials and fabrication techniques and an easing of the "fear-of-failure" concept.

Tubing will probably be the most common form used to clad fuel in the next few years, the exception being naval applications where the cladding is an integral part of the fuel plate. Although tubing can be stainless steel or zirconium, beryllium, columbium and nickel-base alloys (aluminum and magnesium for low-temperature systems), the trend toward low-enrichment fuels gives an advantage to materials with good neutron economy such as zirconium, aluminum, and beryllium. Increased operating temperatures, however, favor refractory alloys. Corrosion and oxidation resistance is still a major problem but there is no one alloy which can demonstrate superiority over the wide range of reactor conditions and designs. Beryllium, zirconium and columbium pose problems of corrosion and fabrication while stainless steels, columbium and high-strength nickel alloys cut the neutron economy.

Present knowledge of irradiation effects is too sketchy to permit optimum engineering of new steels for pressure vessels. These steels must be made with alloying elements that yield respectable properties at the beginning of reactor life, and retain them after 20 years' exposure. Chemical changes resulting from transmutations must be considered. Heat treatments must give conditions at the beginning of reactor life such that irradiation will not appreciably alter them. Acceptance of high-strength alloys will come only if reliability is proven, especially with regard to effect of irradiation on ductile-to-brittle transition temperature.

Designing With Modern Steels



Engineers are realizing more and more that the important commodity their dollar buys in steels is strength, not weight. In spacecraft, atomic reactors, high-temperature steam turbines and chemical plants, the properties of steel are being used to their fullest extent. Furthermore, growing use of modern high-strength steels in large structures, freight cars and more recently in trucks show that good design pays off in lighter weight and lower cost.

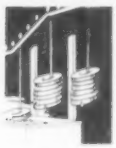
In the auto industry, the high-strength low-alloy steels have been widely used for bumpers. These steels can also be used in strength members and body frames with little or no change in forming practice. Because their strength is higher than plain carbon steels, they can be formed into thinner sections to do the same job. Cost per pound is higher than that of the carbon grades, but savings result because less steel is needed.

Hardenability Bands for Carbon Steels?

Many steel users are interested in hardenability bands for carbon steels. Unfortunately, such bands are generally much wider than those of their alloy steel counterparts and may be of little help to the heat treater who needs to have consistent hardening responses between different heats of a given grade.

Despite these problems, however, hardenability bands for carbon steels seem to be in the offing, since more and more users are demanding them.

Heat Treating: The Fluid Bed Emerges



The heat treat engineer has taken a lesson from technologists working with fluid catalysts. Result: A heat treating and quenching medium which transfers heat some five to ten times faster than normal convection.

The fluidized bed consists of a deep layer of fine, refractory, sand-like particles resting on a diffusion plate. In operation the particles are heated and a stream of air or inert gas is directed up through the diffusion plate into the bed under pressure equal to or slightly greater than the weight of the particles. Thus, the mass of particles is buoyed and kept in suspension and swirls much like boiling water. It is this fluid-like turbulence that provides rapid, uniform distribution of heat (or cold) to metal parts.

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In other areas major advances have occurred in continuous strip handling and in control of metal surfaces. For example, metal strip is being continuously annealed at well over 2000° F. and at speeds as high as 2000 ft. per min. in furnaces designed to eliminate marking or other surface alterations of the strip during heating or cooling. Surface is protected (as in the bright annealing of stainless strip) by proper choice from a wide selection of protective gases including argon, pure hydrogen, pure nitrogen, or endothermic atmospheres. Improvements in techniques and equipment for producing these gases can be expected to continue. The problem of atmosphere control has been approached in a number of ways but control of the water content is proving to be the most universal method and the cheapest to maintain.

Refrigeration equipment is likely to be more widely used in the future. With the close tolerances that are required in many types of operating machinery, parts such as precision gears for miniaturized equipment must be machined and heat treated to precise dimensions. Cold treatment after quenching is often needed to convert residual austenite completely to martensite. Gas drying is another predicted field for refrigeration. Engineers postulate that atmospheres with dew points of —150° F. could be produced if the gas is cooled to where the water freezes out as minute crystals of ice.

Stainless Steels Vie for Broader Use

Use of the 200 series steels continues to expand because they are somewhat less expensive and have higher strengths than the 300 series, to which they are otherwise comparable. A new one has a yield strength above 70,000 psi. in the annealed condition. It is being used where high strength, good corrosion resistance, and low magnetic permeability (or a combination of any two of these) are required.

Precipitation hardenable steels with higher strengths will probably become available in the future. Furthermore, there is some indication that they will be used to a greater extent in the cold rolled and aged or tempered condition by the aircraft and missile industry because such treatments give a combination of high strength and good ductility. There are large possibilities that weldability and microstructural stability of the precipitation hardenable alloys will be improved by small additions of some of the "new" or rare metals now becoming available, and whose utility can only be guessed. It is known, for example, that the size of precipitated particles, their distribution in the grains, the amount collected at grain boundaries and the impoverishment there, can be influenced for the better if a little silver is added to the high-strength Al-Zn-Mg alloys.

Research indicates that the resistance to crevice corrosion of Type 430 may be increased substantially by changes in composition; this should result

in new alloys for automotive and other applications. There is also a reasonable expectancy that a lower-priced stainless steel will be developed for uses where the corrosion resistance requirements combined with economic considerations do not justify present steels.

Titanium Looks to the Future

Declining metal and fabrication costs are helping titanium become more a working metal than a subject for technical papers. For example, the price of titanium heat exchangers has dropped to about $30 to $35 per sq. ft. of exchange surface. In two plants handling hot inhibited sulphuric acid, 45 titanium heat exchangers were ordered when cost studies showed that equipment with an expected life of at least ten years could be built for $1456 per unit compared with lead-covered copper equipment at $1111 and a service life of nine months. This nonmilitary application demonstrates a growing market for the metal.

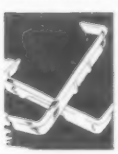
New alloys, which were introduced at a bewildering pace in the mid-50's, are now appearing much more slowly as titanium producers channel their efforts toward existing products. Three weldable alloys comprise the titanium used for missiles. These include the beta alloy (13% V, 11% Cr, 3% Al) for maximum strengths at the least weight; the 6% Al, 4% V alloy for operation from −320° F. to 1000° F.; and the medium strength titanium alloy containing 5% Al, 2.5% Sn, which shows great promise for vessels for liquid hydrogen (−423° F.).

Copper: New Advances for Better Products

Copper is fighting tough battles with other metals. Several programs have been launched to recapture lost applications and to hold those which are threatened. Thinner, stronger brass sheet for auto radiator tanks is now available and a new 70-30 cupronickel tubing alloy, some 30% stronger than the standard alloy, is being used for chemical and petrochemical processing equipment. It is also expected to find applications in high-pressure feed water heaters.

The industry has long recognized that a demand exists for a tarnish resistant copper. The Copper Products Development Assn. recently let two research contracts for work along these lines. One approach will be controlled surface oxidation — formation of a transparent film by selective oxidation of minor alloying elements added to the metal.

Aluminum Maintains Its Fast Pace



It's not news that aluminum is gaining in many areas. During 1961 automotive uses of the light metal are expected to show a 14% advance over 1960. Further increases will come from the introduction of aluminum bumpers and radiators on a wide scale within a year or two. For radiators, much work is being done on furnace brazing techniques similar to furnace soldering—the procedure for making brass radiators. In converting to aluminum, manufacturers would thus be able to hold their capital expenditures to a minimum.

In the aircraft industry the excellent weldability of 2219 has prompted designers to consider this aluminum-copper alloy for use over a wide temperature range. In the Bomarc B missile, 2219 sheet is welded into high-strength fuselage and fuel tank sections. Alloy X 2020, containing 1.1% Li and 4.5% Cu, is the strongest aluminum alloy for use at 200 to 400° F.

Magnesium Builds on Commercial Uses

The magnesium industry believes it will soon see 80 to 90% (compared to the present level of 50%) of its total production going into down-to-earth applications. Good examples of the trend are the die-cast dash panels on 1961 Chevrolet and Dodge Lancer, for which magnesium was selected solely on the basis of lower cost. These applications point out the increasing demand for magnesium in the automotive, commercial transportation and materials-handling field. More designers are recognizing that the low weight of magnesium leads to economic advantages which can be realized not only in die castings but in sheet and extrusions as well. The incentive of greater payloads will stimulate further growth.

Aerospace Needs Spur Beryllium

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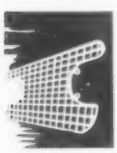
Beryllium is continuing its advance as a constructional material in the aerospace industry. The average price of fabricated shapes has decreased about 50% in the last two or three years, a trend that is expected to continue as production and sales volume increase. Successful results in welding and brazing beryllium have been reported and hot pressed, high-purity billets (enclosed in steel jackets) are being rolled, extruded and forged.

Sheet rolling of beryllium is approaching commercial reality, although consistency of texture, properties and tolerances are still unsatisfactory. Sheets as large as 24 x 84 in. with thicknesses down to 0.040 in. have been produced. Smaller sheets have been rolled to 0.010 in. Research shows that ductility of beryllium may be greatly improved at very high purity levels.

New Plating Systems Take Hold

New plating techniques and accelerated corrosion tests ("CASS" and "Corrodkote"), which closely correlate to service, are improving the quality of electroplates. Spurred by auto makers who have insisted on better corrosion resistance, the new plating practices are based for the most part on duplex nickel consisting of a deposit of about 0.001 in. of semibright nickel followed by thinner layers of bright nickel and chromium.

Duplex nickel, has been well received both here and abroad. In this country some 25% of the nickel plating solutions being marketed are going into such systems. Chrysler Corp., served by some 200 plating shops, has specified duplex nickel for all exterior electroplated parts on its cars. This requirement came after a test program which showed that coatings of ordinary chromium over duplex plate of the same thickness as the old bright nickel-chromium system gave up to four times better protection.



In comparison with duplex nickel, improvements in chromium plating are of more recent origin. Crack-free chromium was first adopted commercially about two years ago, and dual chromium is more recent than that. Reports from several sources have demonstrated the efficacy of crack-free chromium for delaying and reducing corrosion pitting in duplex nickel coatings. New techniques promise improved covering power, broader bright plating ranges and better throwing power, making it easier to plate complex zinc die castings. To this end, use of special anodes for plating in recesses is increasing.

Dual chromium is deposited over bright nickel as a layer of crack-free chromium followed by a second layer containing numerous microcracks. Such composites give improved protection against corrosion and damage by particle impingement. Major problems receiving attention in the research laboratories are the tendency for staining and the difficulty of washing off road films from surfaces plated with microcracked chromium.

Metal Cleaning and Surface Treatment

In the expanding field of pre-paint treatments, improvements are being made in phosphate and chromate conversion coatings for greater adaptability in processing and subsequent operations and better protection against corrosion. These improved treatments will play an important part in pre-finishing metal stock before fabrication.

Some important achievements in metal finishing chemicals during the year ahead are expected for the light metals. New cleaners will be available for removing buffing compounds from aluminum without metal attack. Cleaning before bright dipping—an industry headache—will be simplified and improved. The bright dip baths themselves are undergoing much scrutiny. There is a good chance that improved baths will be available before this year is out.

Magnesium, long handicapped because of its relatively poor corrosion resistance, will be re-evaluated by many because of a promising stannate film treatment. This new immersion coating process inhibits corrosion, particularly in salt-laden road splash and marine environments.

Learn More About Welding

Engineers and designers need to take a closer look at welding because lack of understanding of its true capabilities has helped create an aura of suspicion and distrust. The simple process of depositing weld metal which is stronger than the base metal provides a safety factor which often offsets the detrimental effects of porosity, notches and questionable penetration. What is needed is a combination of proper design and enough inspection to insure quality based on greater confidence in welding than now exists. Too often the alternative has been to overdesign and perform unrealistic inspection more stringent than required by established codes which already are conservative. Much of the economic benefit of welding is thus lost.

More structures are being fabricated today by welding components in the shop and transporting them to the construction site for final assembly. Welding is also making slow inroads in the machine tool industry. One of the hurdles here is the prevalence of captive foundries. Also, machine tool bases, where most of the potential for welding exists, represent only a small portion of the total cost of the equipment.

Testing Keeps Up With Modern Technology

Progress in the aerospace and nuclear industries has demanded new methods of nondestructive testing. Strain hardening such steels as 17-7 PH has been handicapped, for example, because results of hardness tests do not correlate with the tensile strength after hardening. After intensive work, eddy current testing equipment with special probes has reliably predicted strength during stretching. The desired properties are now obtained in the entire stretched sheet.

Currently, the already widely used tests such as magnetic particle, fluorescent penetrants, and X-ray, are moving into new control functions in manufacturing. An example is use of automatic magnetic particle inspection in conditioning steel billets to increase yield of wire, rod and tubing and improve the integrity of the final product. Fluorescent penetrants are serving a similar purpose with stainless steel and may do so in high-strength aluminum.

In film processing, a number of improvements have been made which result in significant cost savings. X-ray film is now being packaged as single sheets which are ready for exposure. The prepacked sheets are useful in

X-ray inspection of aluminum, magnesium, thin steels and other objects where a lead screen is not required.

Automatic processing of X-ray film marks another important step in nondestructive testing. This equipment cuts labor costs and filmhandling significantly and reduces the processing time. In one plant labor savings amounted to $35,000 annually. Fully automatic photoelastic stress analysis is also visualized in the near future, since this technique is adaptable to photographic and photocell systems, television and direct vision. Manufacturers of automobile engines are also employing this method of stress analysis as a designing aid.

The future may also see the application of photoelastic techniques in acceptance inspection. For example, a pressure vessel could be sprayed with photoelastic plastic. Permanent strains, if existing, will show up after tests as a permanent color pattern on the photoelastic coating when the pressure is released. This could provide a direct means of rejecting or accepting structures.

Technology Forecast '61

The advent of semiconductors as a strain-sensitive device has aroused a tremendous interest in industry, since it has a strain sensitivity about 100 times higher than that of metal strain gages. Several difficulties such as linearity problems, ductility and temperature compensation still exist, but it is felt that these will be overcome in the future and the semiconductor strain gag will become a useful tool.

A Step Forward for Metallography

One of the most versatile instruments available to metallographers today is the microprobe analyzer, an instrument which can analyze areas as small as 0.1 micron. Although expensive—it costs from $60,000 to $125,000—the equipment has great potential in problems involving diffusion in binary alloys, analysis of precipitates, segregation, inclusions, identification of phases and determination of solid solubilities. It is quite possible that, as more metallographers recognize the great value of the analyzer, demand and competition may bring its price close to that of a high-quality electron microscope.

Foundries Count on Improved Techniques

To a great extent foundries are looking to the high alloys to provide the improved temperature and wear resistance demanded by modern technology. Use of vacuum melting and pouring will be pushed where low-metalloid and low-inclusion steels are required. Melting and pouring in vacuum or controlled atmospheres such as argon often result in castings with improved properties, but its real value lies in parts which possess more uniform properties regardless of changes in section.

The ceramic shell process has given the investment casting industry new hope in competing with forgings and machined parts. While a few years ago such castings weighing a few pounds were considered large, producers now look to obtain castings of 25, 50 and, in some instances, 100 lb. at competitive prices. Much of the success of the process comes from lower material costs and shorter processing time. Techniques are now under study for making ceramic shell molds automatically or semi-automatically.

Recent achievements in precision casting methods are opening up new possibilities for cast-to-shape tooling made to close dimensions with surfaces that require little or no machining. These methods will probably be applied first to hot work dies for forging, plastic molding and die casting. The market for these products is still uncertain, but considerable activity may be expected along these lines during the coming year.

The Trend in Vacuum Melting

Now that vacuum melting processes have achieved status as recognized production tools this is a good time to reappraise them. This question remains: "Which method—vacuum induction melting or consumable arc remelting—is best for the particular application?" There seems to be a swing towards consumable arc remelting, primarily because it can produce the largest heats.

Practices in air-melting furnaces have also improved to the point that virtually any alloy can be produced. Though their cleanliness may not be quite up to the standard set by a good vacuum-melted heat, this can be compensated for by remelting the air-melted ingot in a vacuum arc furnace.

As a sign that this may well become the accepted practice, larger consumable arc furnaces are being constructed. Soon to be in production is one designed to produce 40-in. diameter ingots weighing up to 50,000 lb. If the demand warrants—and it seems likely to—the unit can be enlarged (by changing crucibles and adding to the power capacity) to produce 60-in. ingots. Not to be overlooked are the advances being made in vacuum degassing which promise to give improved quality in many grades of ordinary steels with a very moderate increase in cost.

Oxygen Stirs the Steel Industry

Of all the forecasts that one could make, the safest one probably is, "Steel producers will use more oxygen next year." From every quarter of the land—and, in fact from every quarter of the globe—comes news of steelmakers who have added oxygen capacity. A striking example of this is the recent announcement that one major company will construct two basic oxygen converters, each of which will produce 300 tons of steel at one time. The expected production rate is a phenomenal 200 to 250 tons per hr.

Most of the new oxygen capacity is apparently intended, however, for existing smelting and refining units (blast furnaces, openhearths, and electric furnaces). One estimate has it that iron and steel capacity in this country could be doubled by merely converting all present-day melting and refining equipment to the use of oxygen. Thus, steelmakers could go for years without building any new blast furnaces or openhearths; all they would need is new oxygen plants. (The steel industry is now using about one half of all the liquid oxygen produced in this country.)

As a sign of this interest in converting existing equipment, steelmakers are investigating the Mearz-Boelens openhearth, a new European furnace with a "streamlined" interior. In this all-basic furnace the front and back walls slope inward to the roof so the vertical cross section has a semi-elliptical shape. Conventional openhearths can be readily altered to this new design which steelmakers feel is more applicable to oxygen operations because it permits a more even gas flow. To date, many European shops have these furnaces, and one company here has installed a modification which produces 180 tons per heat.

From the Four Corners

The main thing to look for from our foreign colleagues and rivals is competition—continued, unremitting, unrelenting, and extremely able. For one thing, every nation, no matter what its size or economic position, seems to be adding to its steel capacity. In particular, this is true of the U.S.S.R. According to representatives of that country's State Planning Commission, well over 90,000,000 tons of steel will be produced every year by 1965. In 1970, they expect 120,000,000 tons a year. To meet these grandiose goals,

existing plants are being modernized and new plants are being built. In 1959, the Russians began operating three new blast furnaces, ten new openhearths, three electric furnaces, two bessemer furnaces, seven rolling mills, and five coking batteries. Last year, five blast furnaces, ten large openhearths, three electric furnaces, six rolling mills, and eight coking batteries were to go into operation.

India and Japan are also making great strides. India's third five-year plan, to begin this coming April, is intended to raise ingot capacity to around 11,000,000 tons per year, and her goal is to produce over 50,000,000 tons yearly by 1975. Japan produced 20,000,000 tons last year, and by 1970 she plans an ingot tonnage of about 42,000,000 annually. The English are devoting much of their effort to modernizing existing capacity, particularly by adding automatic controls to melting, rolling, and forming equipment. They are also doing quite a bit in the continuous casting field; they feel that this technique cuts out heavy rolling schedules and the need for soaking pits. Four companies are planning two and four-strand installations, and two of them expect to be producing by the end of 1961.

Technology Forecast '61

A Computer in Your Future?

In the future, computers of all types and sizes will solve many of the knotty problems which appear every day in industry. Digital computers are also being used more and more, particularly in steel mills. New rolling and finishing facilities built at one large mill include a 53-in., two-high reversing blooming mill which is automatically controlled from schedules set up on punched cards. Methods are also being developed to operate coke plants and pickling baths automatically.

Computers are being used by steelmakers in calculating charges for openhearths. With the advent of the oxygen steelmaking processes and the drop in sales, scrap prices have varied considerably. Naturally, it is best to use more scrap when it is cheaper. However, the large number of variables implicit in steelmaking make it extremely difficult to judge the optimum amount of scrap to charge when it is at any given price. This is where the computer comes in. It can solve blast furnace and openhearth charging problems in much less time than it would take a crew of talented mathematicians.

Computers and automatic controllers are being widely employed in England. In forging, rapid heating practices tied in with automatic operation save much in fuels; in rolling, it is expected that all rolling schedules will eventually be made automatic.

Literature Searching for Lower Research Costs

In an editorial in **Science** last summer, Dael Wolfe asked the question: "How much research for a dollar?" after he discovered that the United States, in investing $13 billion for research in 1960, was spending 4½ times as much as in 1950 to buy only twice as much research. One major reason why research productivity has declined steadily is the inadequate availability and, hence, ineffective use of recorded knowledge. It has also been estimated that **not** finding information when needed is costing us $1 billion a year.

To combat these roadblocks in technological progress, industry is turning more to electronic literature searching. For example, it is expected that during the year several machine searching systems will be installed in companies and plants based on "tape libraries" of metallurgical literature provided by a central source. Fortunately, the metals industry occupies a leading position in these efforts. It will not lose this during 1961.

Critical Points

By the EDITORS

Red Cloud in the East

NORMALLY, WE ARE NOT CONCERNED with the political situation, preferring instead to confine our efforts to technical advances in the metals field. However, when we found that metals engineers both here and in Free Europe were helping – yes, we said *helping* – the Russian side of the cold war, we thought that something should be said about it.

In the first place, of course, you might be wondering about this surprising statement. Well, let's have the design chief of a Russian camera plant explain it for you. With unbelievable candor, he speaks (in Joseph Novak's recent book, "The Future Is Ours, Comrade") as follows: "Just think of how much human energy is wasted in countries like the United States, where hundreds of competing factories, inventors and scientists work only to bring out new models of household appliances. Out of their furious rat race of talent and creative brain power, every now and then they produce the perfect refrigerator or the ideal fountain pen. Then we take over the design and mass produce it. Quite an economy for the State, isn't it?"

Though you can probably guess what all of those Russian engineers are doing in their "planned economy", where every one does what he is told to do and no questions asked, let this unusually informative camera "designer" make it very clear. "We push progress in nuclear energy, chemistry, applied mathematics (computers and calculators), and so forth, which are revolutionary in technique. Our most capable, most experienced scientific and labor cadres are concentrated there, and thousands of our able technicians, engineers and chemists find their way into the key revolutionary industries which will insure our domination of the world." In other words, the Kremlin is more interested in swords than in plowshares.

Is it possible to fight such an insidious technique? We cannot build a fence around our creative talent – such a fence would shut out more than it would keep in. Even our most competitive American firms long ago discovered that truism. Our very way of life is built on competition – competition between persons, companies, even states and nations. In fact, without this competition – which has always acted as a spur to our inventive efforts – our very reason for being is gone. And while it seems that this competition is providing the Iron Curtain countries with any number of fine designs to be "adapted" for their own use, perhaps we should not worry too much. Let us keep on staying five to ten years ahead of the imitators.

In this, we members of the technical societies are in a somewhat unique position. Cooperation, not competition, is the essence of any society such as the A.S.M. Our members, though they include engineers from competing companies, meet constantly to share their knowledge. Without this cooperation (which is entirely voluntary), we would be duplicating research and wasting time on nonessentials.

However, are we really doing enough? As observers of the metallurgical scene, we would like to find out. You, as engineers and A.S.M. members, undoubtedly have ideas of your own concerning the unraveling of this major cold war enigma. What is your answer?

Report From West Germany

New Carburizing Steels in German Automobiles

*By H. U. MEYER**

Comprehensive research into the nature of case hardenability has led to the development of carburizing steels in which the major alloying element is molybdenum. These new steels have been successful to the point where they have replaced standard carburizing grades in German automobiles despite their higher cost. (J28g, J5, 2-60; AY, *Mo*)

BASIC INFORMATION on the concept of "case hardenability" has led to several new carburizing steels in Germany. After successful tests with specimens and particularly with components, these new alloys have been adopted by many large automobile and truck plants. One typical example is 20MoCr4, a steel containing 0.20% C, 0.70% Mn, 0.45% Mo, and 0.40% Cr. Further development of this basic type includes 25MoCr4 (the same analysis as 20MoCr4 except that it has 0.25% C), and 20NiMoCr6 which contains 1.5% Ni as well as 0.45% Mo and 0.40% Cr.

While each type has specific uses, the property common to all is good "case" hardenability. To explain more fully, the key property of carburizing steels is their ability to form a surface layer which is resistant to wear and compression, and also has the compressive stresses needed for optimum fatigue strength. The main question is then, "Is the carburized layer adequate?" In other words, the "more suitable" of any two steels having equally satisfactory mechanical and processing characteristics will be the one which will develop a suitable carburized layer more easily, more reliably, or more economically.

*Director, Climax Molybdenum Co., Zurich, Switzerland.

Some Background

As is well known, the last few years in Germany have witnessed an intense upsurge in mass production, especially in the automotive industry. This industry has devised many ingenious procedures aimed at increasing output and reliability of production, and, as much as possible, improving the product. These have led to similar advances in the field of carburizing steels. In particular, gas carburizing and subsequent direct quenching have aided the trend toward a more reliable, more economical product.

Direct Quenching Is Feasible

Direct quenching – or quenching a part carburized at around 920° C. (1700° F.) directly in oil – has until recently been considered such

Production Lines of the Volkswagen Plant in Wolfsberg, West Germany

a brutal treatment that it was seldom recommended for critical parts. However, during the development work, it became clear that a great deal could be gained economically if it were possible to create an alloy particularly suitable for gas carburizing and direct quenching.

Gears, being the most important and critical product made of carburizing steels, merit special attention. Several factors must be considered in their treatment. For example, the carburized layer must be resistant to wear. For this property, a high hardness is needed; a high-carbon martensite with little residual austenite and few carbides is believed to be the best microstructure. Also, the carburized layer must transmit high pressures without indentation, and there must be no plastic deformation anywhere under the surface.

Every gear failure, whether it occurs by fracture, wear or pitting, starts at the surface or

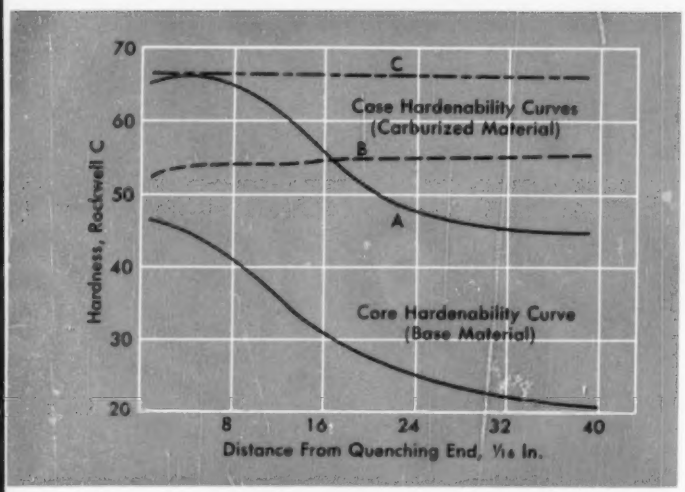


Fig. 1 – Schematic Representation Showing Three Steels With the Same Core Hardenability, but With Different Case Hardenabilities. Lower curve represents the core hardenability of steels A, B and C

immediately under it. Consequently, special attention must be devoted to the case – and the case hardenability determines the case character.

The concept of case hardenability has proved to be a useful criterion for choosing carburizing steels. Its determination is simple: The well-known "Jominy* bar" is carburized, end-quenched, and the hardness of the cylindrical surface is measured at accurately determined case carbon contents.

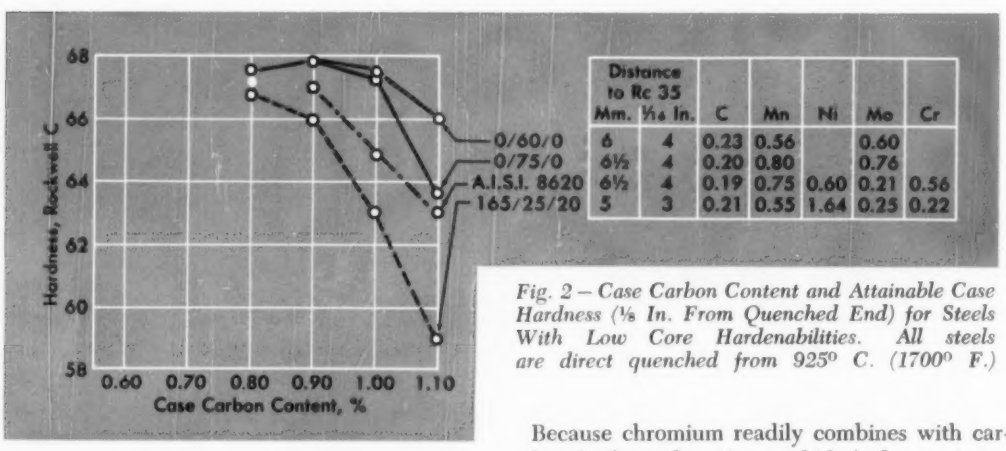
It is important to know the case hardenability of a steel because steels which have the same core hardenability can have entirely different case hardenability curves – as Fig. 1 shows. As a result, steels which are considered to be best for carburizing are those which have, for a given core hardenability, the highest case hardenability with highest maximum hardness.

Earlier Investigations

In earlier work, researchers compared case hardenabilities of three low-alloy steels with the case hardenability of an unalloyed carburizing steel. Hardenabilities at three carbon levels, 0.90, 1.00 and 1.10%, were determined to simulate commercial carburizing practices.

The four steels gave different case hardenability pictures. With carbon, nickel-molybdenum, and straight molybdenum steels, the lowest case hardenability was found at 0.90% C. On the other hand, the manganese-chromium steel had the deepest hardenability at 0.90% C, and this hardenability decreased sharply with increasing carbon content. Varying case carbon contents seemed to have little influence on maximum hardness and hardenability of the molybdenum steel.

Here, we should mention the characteristic tendency of chromium steels to develop high carbon contents in the case during carburizing.

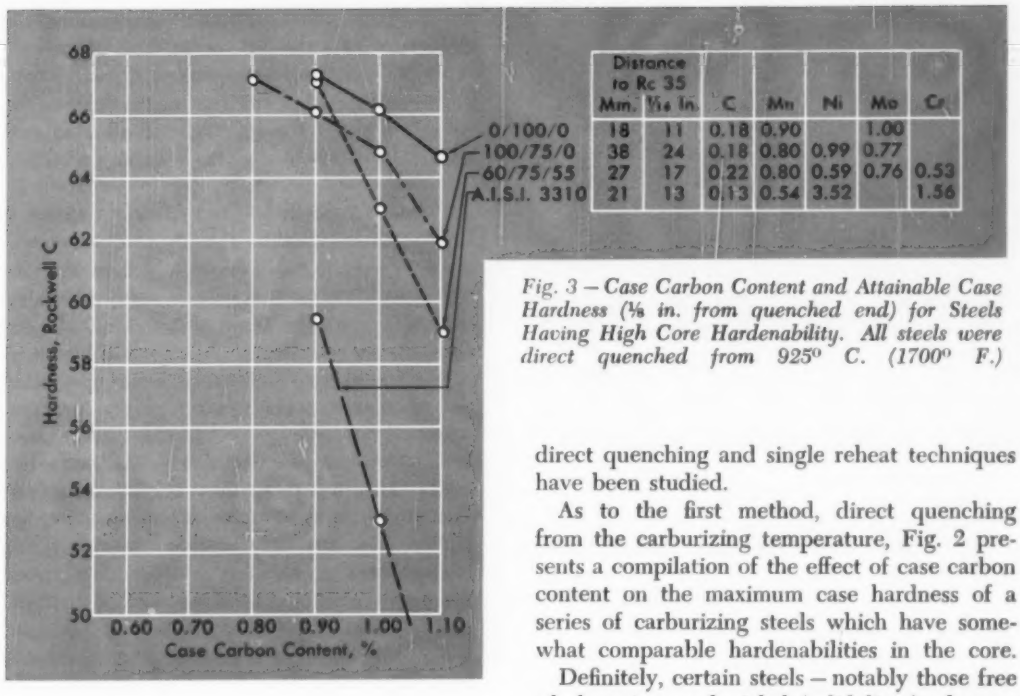


	Distance to Rc 35 Mm.	1/16 In.	C	Mn	Ni	Mo	Cr
0/60/0	6	4	0.23	0.56		0.60	
0/75/0	6½	4	0.20	0.80		0.76	
A.I.S.I. 8620	6½	4	0.19	0.75	0.60	0.21	0.56
165/25/20	5	3	0.21	0.55	1.64	0.25	0.22

Fig. 2 – Case Carbon Content and Attainable Case Hardness (⅛ In. From Quenched End) for Steels With Low Core Hardenabilities. All steels are direct quenched from 925° C. (1700° F.)

Because chromium readily combines with carbon (to form chromium carbides), the maximum hardnesses and hardenabilities of chromium-

*The end-quench test, as first devised by Jominy and Boegehold (see A.S.M. *Transactions*, Vol. 26, 1938, p. 574) was intended to grade the case hardenability of carburizing steels. Since the test was immediately adopted for rating the hardenability of low-alloy steels, its original reason for being has been largely forgotten.



Distance to Rc 35 Mm.	Distance to Rc 35 1/16 In.	C	Mn	Ni	Mo	Cr
18	11	0.18	0.90		1.00	
38	24	0.18	0.80	0.99	0.77	
27	17	0.22	0.80	0.59	0.76	0.53
21	13	0.13	0.54	3.52		1.56

Fig. 3 – Case Carbon Content and Attainable Case Hardness (1/8 in. from quenched end) for Steels Having High Core Hardenability. All steels were direct quenched from 925° C. (1700° F.)

containing steels are particularly sensitive to varying heat treatments. To obtain the desired results, such steels require special attention as well as special equipment and procedures, all of which can amount to considerable expense.

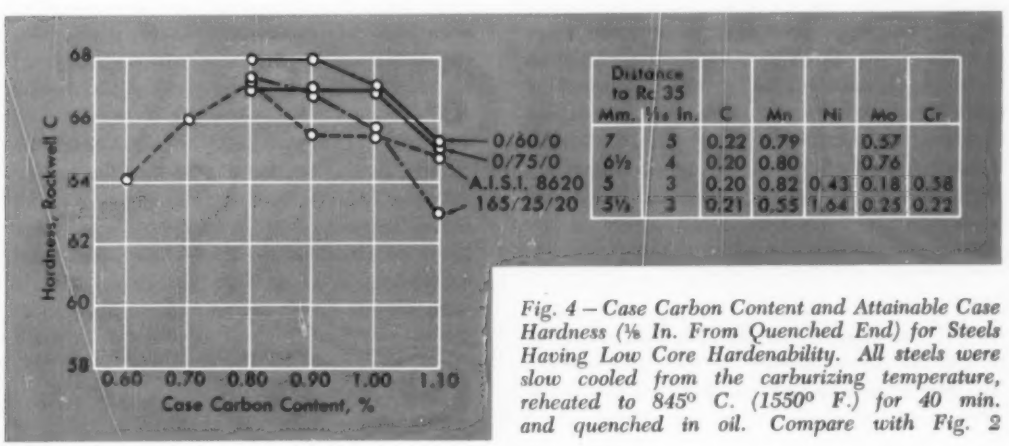
Newer Investigations

In later research, workers have evaluated a large number of case hardenability curves to arrive at evidence as to the maximum case hardness of steels having different base hardenabilities – that is, different core strengths. Both direct quenching and single reheat techniques have been studied.

As to the first method, direct quenching from the carburizing temperature, Fig. 2 presents a compilation of the effect of case carbon content on the maximum case hardness of a series of carburizing steels which have somewhat comparable hardenabilities in the core.

Definitely, certain steels – notably those free of chromium and nickel (solid lines) – have a higher maximum hardness at equal or higher carbon contents than those which contain either chromium or nickel. Similar tests with a group of steels having medium core hardenabilities (A.I.S.I. 4320, 8822 and 4817 for example) produced a similar picture.

Figure 3 shows the maximum hardness values of a group of steels – some experimental – with high core hardenabilities. Comparison of the maximum hardness of the nickel-chromium steel (A.I.S.I. 3310) with those of the other alloys leads to the supposition that it is feasible to



Distance to Rc 35 Mm.	Distance to Rc 35 1/16 In.	C	Mn	Ni	Mo	Cr
7	5	0.22	0.79		0.57	
6½	4	0.20	0.80		0.76	
5	3	0.20	0.82	0.43	0.18	0.58
5½	3	0.21	0.55	1.64	0.25	0.22

Fig. 4 – Case Carbon Content and Attainable Case Hardness (1/8 In. From Quenched End) for Steels Having Low Core Hardenability. All steels were slow cooled from the carburizing temperature, reheated to 845° C. (1550° F.) for 40 min. and quenched in oil. Compare with Fig. 2

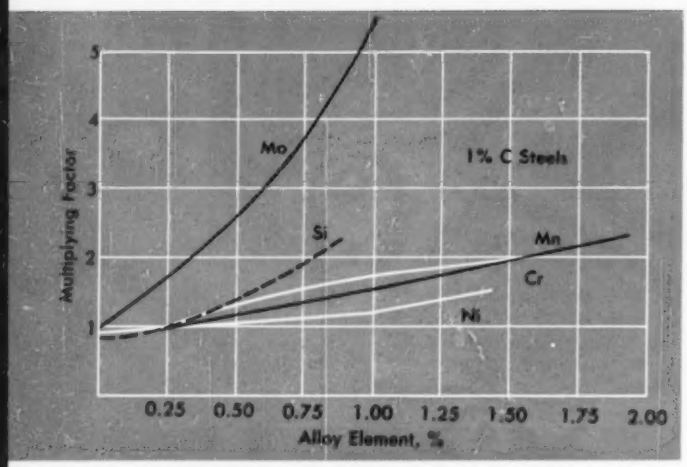


Fig. 5 – Multiplying Factors for Calculating Hardenability in 1% C Steels by the Jatczak-Girardi method. These factors are applicable to the calculation of case hardenability

develop steels with maximum core strength that are not sensitive to degree of carburization, duration of austenitization, and austenitizing temperature, but nevertheless have good maximum hardness.

Single Reheat After Quench

To counter the possible assertion that certain steels would be especially good for direct quenching (thus implying they would not be effective if treated with single reheat quench), we investigated the behavior of various alloys with a reheat quench – slow cooling from carburizing followed by a regulation quench and temper. The results, as Fig. 4 shows, indicate that the solid curves – those for the steels which have no nickel or chromium – have hardly moved from the positions they hold in Fig. 2. It can be seen that these steels react just about the same to long austenitizing at high temperature (as for a direct quench) as they do to a repeated shorter austenitizing period at only 845° C. (1550° F.). The illustrated curves are for steels with low core hardenabilities; steels with medium and high core hardenabilities react in like manner.

Calculating Case Hardenabilities

To avoid the need for testing many steels for case hardenabilities, the calculation system of Jatczak and Girardi* can be used. Much like the system developed by Grossmann for hypo-eutectoid steels, their method is useful for steels containing 1% C. Furthermore, this method is as valid for carburized cases as it is for high-carbon homogeneous steels. Figure 5 illustrates curves for the multiplication factors; they show the influence of alloying contents on the hardenability of cases carburized to about 1% C.

Through calculation, a systematic series of imaginary compositions with the same core hardenability (1.65) was set up; then the case hardenabilities for these steels were calculated. In this manner, the effect of individual alloying elements on case hardenability could be found.

We found that relatively little manganese and chromium were needed to produce core hardenability. Manganese and chromium, however, are much less effective in the carburized case. Also, comparatively large amounts of nickel are required to establish core hardenability; nickel is only weakly effective in the carburized case as well. Nevertheless, since comparatively large amounts are present, good case hardenability finally results. Molybdenum is the only element that is highly effective at both high and low levels of carbon. This explains its strong influence on both maximum hardness and hardenability of the case.

Summing up the experimental work, the following picture emerges.

- Steels with molybdenum and without chromium and nickel produce higher attainable hardness with equal case carbon content, or comparable hardness at higher case carbon contents. At the same time, these steels have the most favorable hardenability.
- Steels alloyed mainly with nickel and supplemented with manganese, chromium or molybdenum show the lowest attainable hardness. As a consequence, they have their maximum hardness at lower case carbon contents than have any of the other steels studied. On the other hand, steels alloyed mainly with nickel, particularly the nickel-molybdenum steels, have high hardenability.
- Steels alloyed wholly or mainly with manganese and chromium appear to be intermediate with respect to attainable hardness. As far as hardenability goes, they are below the level of steels alloyed only or mainly with molybdenum, as well as those alloyed mainly with nickel, or nickel and molybdenum.

*Multiplying Factors for the Calculation of Hardenability of Hypereutectoid Steels Hardened From 1700° F.", by C. F. Jatczak and D. J. Girardi, A.S.M. *Transactions*, Vol. 51, 1959, p. 335.

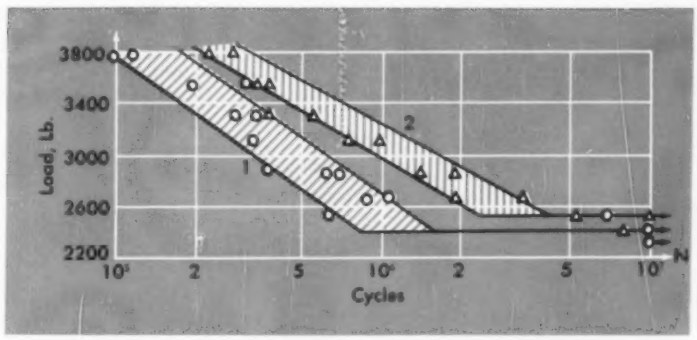


Fig. 6 — Pulsating-Stress Fatigue Tests on Identical Gears Made From Two Steels, 20MnCr5 (1) and a Chromium-Free Grade with 0.5% Mo (2). Though Steel 2 was direct-quenched, it had better fatigue strength than the first

Practical Application

While these test results have shown that (based on case hardenability criteria) these new steels behaved better in carburizing and hardening than others, it remained to be determined whether the service performance of actual parts could be improved. (After all, this is the final goal of all technical endeavors dealing with materials.)

In line with this, it has been thought that carburizing steels with more favorable case hardenability would develop a more favorable pattern of residual compressive stress. Therefore, components made from these steels would have better fatigue strengths. As an added feature, it appears possible that the maximum hardness (and, therefore, the maximum residual compressive stress) could be concentrated on the outermost layer of the carburized zone — and this is exactly where the highest stresses occur in structural parts.

Figure 6 depicts the first evaluation of pulsating-stress fatigue tests on carburized and hardened gears made of a steel which contained about 0.15% C, 0.5% Mn and 0.5% Mo; they are compared to values obtained for a manganese-chromium steel used in production. As can be seen, the entire fatigue strength band of the chromium-free steel (direct quenched from 1650° F.) was above that of the reheat-quenched manganese-chromium steel. This difference between the two steels aroused considerable interest. The difference seemed particularly noteworthy because the core strength of the chromium-free steel was only 114,000 psi. (The core strength of the other steel was 206,000 psi.)

Finally, the fatigue strengths of two gears, which were identical except that they were made of different grades, were compared. For gears made of 20MoCr4 — the steel which finally resulted from this development — the fatigue strength was more than 20% higher (3040 against 2470 lb.) than that of gears made of 20MnCr5, a manganese-chromium steel.

From these investigations, we have concluded that the practical use of case hardenability information means not only better evaluation of hardenability and attainable hardness, but better components as well. Since processing and fabrication experience with these new steels has been good throughout, earlier expectations can be considered as fulfilled.

Also at hand are favorable reports on the production machining of gears, where 55% of the steel is machined away in one manner or another. In comparison with steels used previously, the new grades machine more easily to better surface finishes. Furthermore, tools last longer. Also, despite fears about distortion, direct quenching has proved successful.

In most instances, the new steels have replaced the lower-cost manganese-chromium steels. Apparently, their higher cost as bar stock is outweighed by their fabricating merits.

Prospects for the Future

So far, we do not know why the various alloying elements behave differently in relation to carbon and cooling rate. Since this question is of fundamental importance, the Max-Planck Institute has started a program that will include investigations of the transformation behavior, the solubility limits, and the amount of carbides and carbide phases in various alloys. Some of the questions raised in practice are being studied in a research program by one of the leading automobile plants. Also, an attempt is being made to learn the effect of carbon content of the martensite, free carbides and residual austenite on the wear characteristics, pitting and fatigue strength of gears.

Creep Testing Machine Meets British Emergency

*By H. ROBSON**

Faced with the urgent task of checking the creep properties of numerous forgings of doubtful quality, engineers at D. Napier & Son Ltd. in London designed and built a creep tester in only five weeks rather than cut jet engine production and wait for replacements. Simple in design and fabrication, the tester can handle up to six creep specimens at one time. (Q3, 1-53)

WHEN D. NAPIER & SON, LTD., recently accelerated the production of Eland and Gazelle gas turbine engines, it found that some batches of turbine disk forgings were not fulfilling the stringent requirements laid down for creep resistance. Since the integrity of these units is absolutely vital, it became essential to introduce 100% creep testing of these parts until a consistent standard of metal quality could be maintained, or curtail production until replacement forgings could be obtained.

Rather than cut production, we decided to embark on a thorough test program. This decision meant that increased testing capacity was also needed. Unfortunately, manufacturers of creep machines and auxiliary equipment could not offer quick delivery, and it was necessary to build the equipment, a six-point creep tester, (Fig. 1), at Napier's Acton works in London. Suitable facilities were available to fabricate and assemble such machines provided that no complex forms or shapes were included in the design.

Construction Advantages

Simplicity of fabrication and assembly from available materials were of prime importance in building the creep tester. These specifications placed certain dimensional limits on some of the components. Also important were restrictions imposed by available laboratory floor space and the high capital cost of the temperature control instrumentation.

With these factors in mind, our designer revived an idea which had been discussed but shelved some years before. It envisioned a radial machine in which several creep tests would be performed in a single furnace. In our design, six creep tests can be carried out simultaneously. This offers the advantage that only one controller is required instead of one for each test point as in the more conventional multi-point equipment.

Built on Central Column

Study of various methods of construction emphasized the advantages to be gained by limiting the over-all size and using a central column to serve as a strain-carrying member, furnace support and lever fulcrum-carrying frame. In this arrangement part of the column operates at furnace temperature, but its mass within the furnace assists temperature distribution. Since we expected that the maximum required temperature would be only 600° C. (1112° F.), it seemed that the scheme was practical.

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*Metallurgist-in-Charge, Creep Testing Laboratory, D. Napier & Son Ltd., London. The author wishes to express his gratitude to J. K. Wilson, chief metallurgist, and the directors of D. Napier & Son Ltd. for permission to publish this paper.

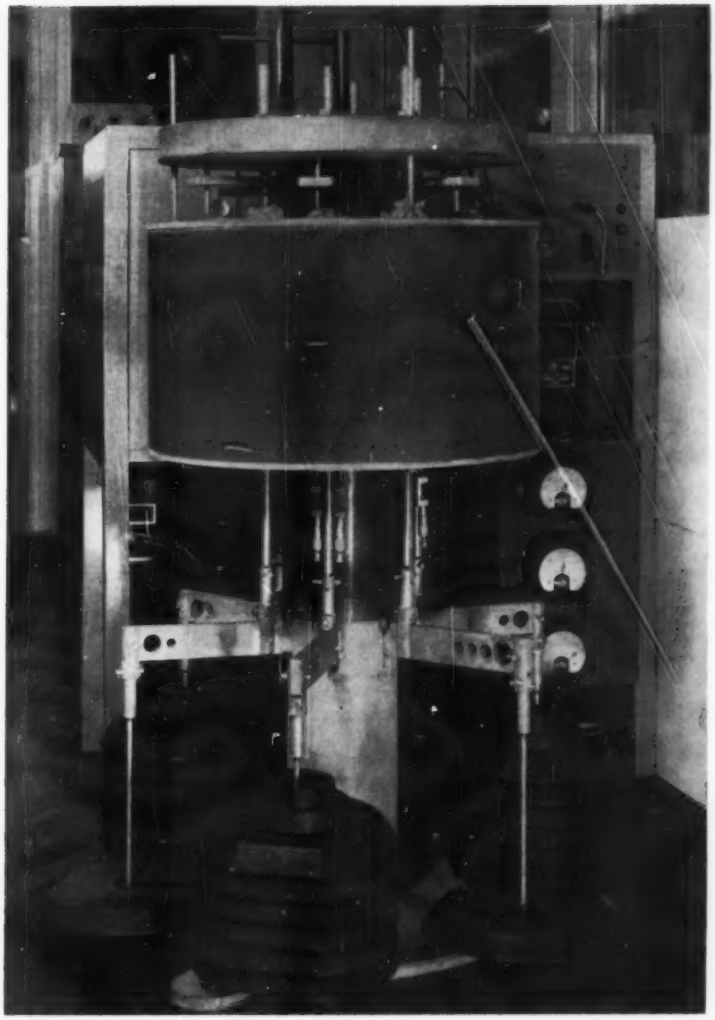


Fig. 1 – Creep Testing Machine Built at D. Napier & Son Ltd. Prevented Bottleneck in Jet Engine Production. Used in an urgent test program to check forgings for turbine disks, the machine can handle up to six creep specimens at the same time

Another important factor in design is that the unit must operate with asymmetric loads. We decided to use a tubular column because of its superior resistance to bending rather than a solid bar. The tube, actually two sections aligned one on top of the other, has a 6½-in. O.D. and 1-in. walls. Both sections are made from bar stock of DTD 306 alloy (a 3% chromium, molybdenum nitriding steel) and are placed in a state of compression by a central axial bar 1 in. in diameter and loaded in tension. This forms the most suitable construction possible to resist bending. It was also nickel plated to withstand test temperatures without scaling. Other steel parts were cadmium plated.

Stress is applied to the specimens through underslung levers which have a mechanical advantage of 5 to 1. This ratio permits enough height from the floor to accommodate cast iron weights for stressing the test pieces. Figure 2 shows the details of the system. The upper knife edges are made from cyanide-hardened mild steel; V-notches in each lever are locally hardened.

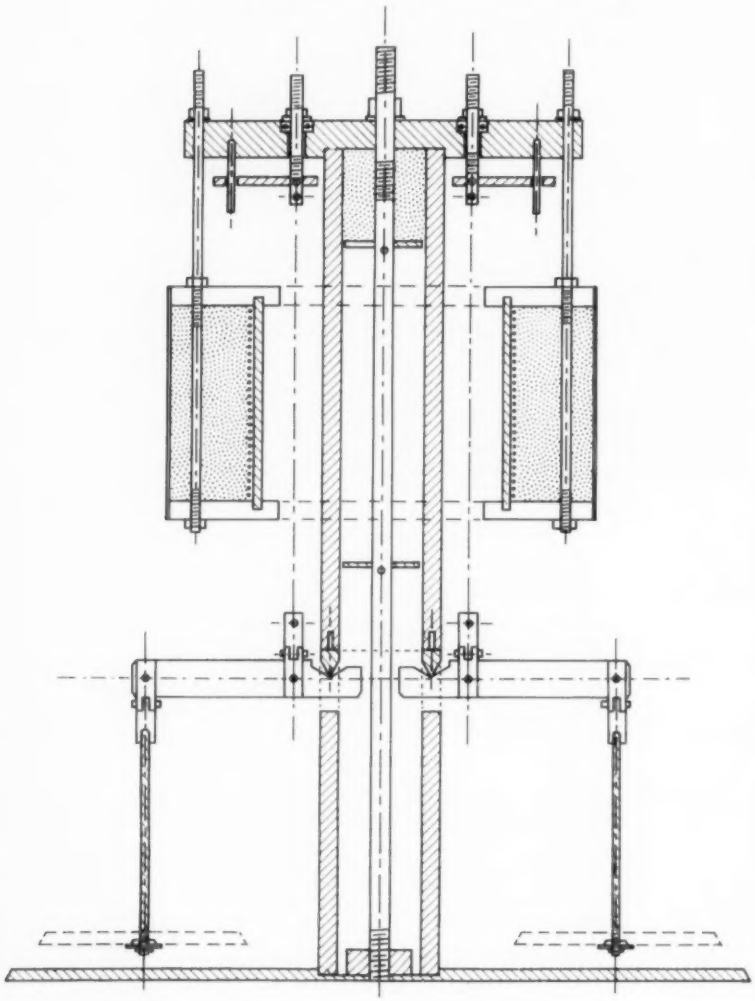
At the top of the furnace the specimens are attached by adapters to screw jacks located to line up with the lever fulcrums. Creep is measured by extensometers capable of reading strain to 0.0033% on a gage length of 1.50 in.

Furnace Control

The electric furnace, built in our creep testing laboratory, contains elements arranged as

three parallel windings with separate terminals at their top ends and a common terminal at the bottom. This arrangement permits us to use a three-phase, neutral power supply with each element on a separate phase. Two elements are fed through slidewire resistances and the third through a 1-kw. saturable reactor. Temperature is controlled by two slidewires which pass enough power to raise the temperature to about 100° C. (212° F.) below the test temperature; the saturable reactor builds up and controls the required balance of power input. In this system the reactor is controlled by an electric relay which in turn is actuated by a platinum resistance thermometer in the furnace. This type of control has been in use here for more than seven years and has proved reliable and efficient.

Fig. 2 – Design Features of Creep Tester. Main member is a two-piece tube held in compression by a central tiebar so it does not bend when exposed to test temperatures up to 600° C. (1112° F.) Tube is also nickel plated to prevent scaling



Built in Five Weeks

Because of the urgency of the situation, we began fabricating some of the parts which could be fitted irrespective of the final dimensions of the central column before complete drawings were prepared. Final assembly of the machine was accomplished within five weeks of the decision to fabricate it, and two weeks were then spent calibrating the levers and checking the temperature gradients and distribution. Three thermocouples were attached to each test piece and a single sheathed thermocouple was placed so that its hot junction was positioned midway between two specimens and level with the midpoint of the test pieces. The maximum deviation over all 19 thermocouples at 550° C. (1020° F.) was less than 1° C. and temperature varied not more than 0.2° C. over a 300-hr. period.

Tests Point Out Precision

In addition, creep tests of 2000 hr. duration were carried out to compare the performance of the new equipment with single-point testers. When six specimens taken from a common forging were tested simultaneously in the new machine, there was less "scatter" in the creep measurements than is normally experienced when six separate tests are carried out in different testers. The mean result was identical with a test carried out on a machine of high accuracy with a test piece of 4.00-in. gage length. Since then, the machine has completed over 10,000 hr. of creep testing without any interruption. Continuous operation is possible because individual specimens can be taken out and replaced without shutting down the machine and without any detectable effect on adjacent tests.

Report From the U.S.S.R.

How the Russians Are Using Ultrasonics in Metallurgy

*By ARTHUR B. TESMEN**

In the Soviet Union, ultrasonic energy is being used to degas molten metals, speed diffusion processes (such as carburization), accelerate aging of aluminum alloys and improve weld quality. Other work with ultrasonics is also being done. (D9, E25n, J-general, 1-74)

IN ULTRASONICS, as in many other fields, the Russians are matching us in both research and development. Since they have not been secretive about their work in this area – many reports of their investigations have been and are being published in their scientific journals – engineers in this country stay well aware of their progress. In the main, most of their research parallels ours. However, there are some differences (the Russians seem to have initiated a greater variety of experiments, for one thing) which should interest metallurgists.

An Early Start

According to their records (and they seem to be accurate), Russian engineers have been working with ultrasonics for some time. Back in 1935 S. V. Sokolov treated molten tin, zinc and aluminum with ultrasonic waves; he found that this vibration changed their solidification rates and produced dendritic structures†. Since then, many patents and papers on the metallurgical effects of sonic and ultrasonic waves have been published throughout the world. According to some of the claims, such treatments degassed melts, refined grain sizes, accelerated rate processes (such as diffusion, with consequent reductions in steel carburizing cycles), and aged precipitation hardening alloys. Ultrasonics were also reported to speed the mixing of molten metal, intensify steel quenching and tempering rates (resulting in increased strengths and hardnesses), and improve properties and deformation characteristics of ingots and castings.

However, the mechanisms of the observed effects are still not completely understood, and some results are even contradictory. The Russians attribute this to the inability of conventional laboratory equipment to provide a sufficiently wide range of frequencies and intensities. They also say that experimental conditions are not constant, nor are measurement methods accurate.

Soviet metallurgists are paying increased attention to ultrasonics, and are aiming at

*Consulting Editor, *Metal Progress;* Materials Specialist, Scientific Design Co., Inc., New York.

†Ultrasonic vibrations induced selective freezing which produced dendrites (unlike the polyhedral granular structure of pure metals and of homogenized solutions).

wider industrial uses, particularly in production and fabrication of difficult-to-work refractory metals and heat resistant alloys. Parallel with this work, they are attempting to mass produce powerful ultrasonic devices for production metalworking.

Some Fundamentals

Before getting into experimental work performed in Russia, we will describe a few fundamentals. Vibrations can be produced by mechanical, electrostatic, electrodynamic, piezo-electric and magnetostrictive transducers. Mechanical vibrations can be produced pneumatically by eccentrically loaded shafts rotating in opposite directions. Other methods employ the flow, or pressure, of air, steam, oil or water. Still others, such as the piezo-electric and magnetostrictive methods, depend upon the changes in the dimensions due to electric or magnetic fields.

Piezo-electric emitters are used for very high-frequency vibrations – up to 1,000,000 cycles or more. Their intensities, however, are usually not great. Magnetostrictive emitters, on the other hand, generate powerful intensities at low frequencies (20 to 60 kc.). Vibration intensity depends upon the material – for example, permendur (49% Fe, 49% Co and 2% V) emits almost 400 w. per sq.in. of surface.

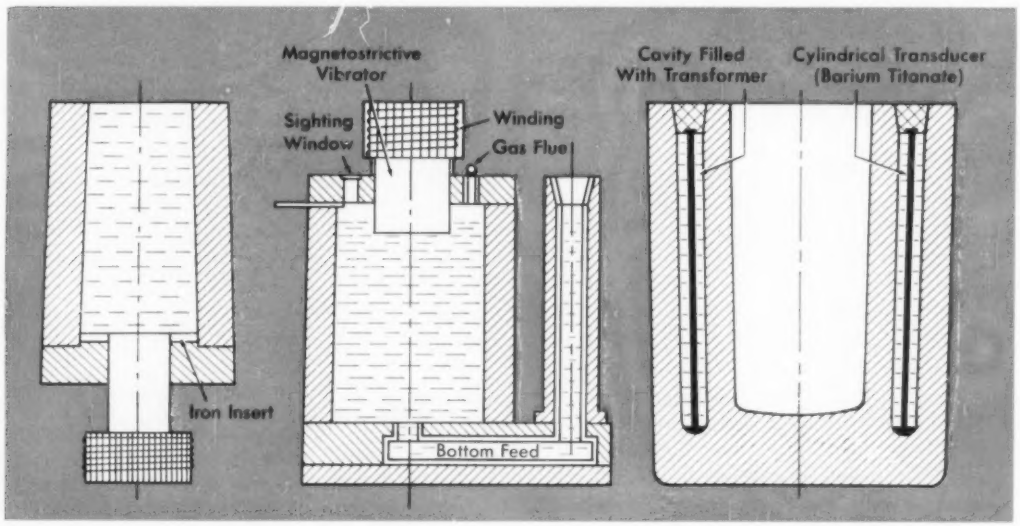
Generators are often used as power sources. The transducers convert electrical vibrations of the generator into elastic mechanical vibrations of the same frequency – in other words, into ultrasonic vibrations. These vibrations are usually transmitted through a medium – often an insulating oil. With these types of transducers – magnetostrictive, piezo-electric, and electrodynamic – the Russians have performed a wide variety of experiments, and, as a consequence, made much progress. Many of their important findings are given in this report.

Improving Ingots

For example, the Byelorussian Railroad Engineering Institute has been subjecting freezing ingots to ultrasonic waves to investigate their effect upon metal composition, structure and properties. Ingots of rimming steel were cast by three methods: in a cylindrical mold with a magnetostrictive transducer on the bottom (Fig. 1, left); in a square mold with a magnetostrictive transducer on the top (center); and in a cylindrical mold with a piezo-electric (barium titanate) transducer placed in the hollow of the mold wall (right).

While an untreated ingot (cast for comparison) contained 0.059% O_2 and 0.026% N_2, the ultrasonically cast ingot showed only traces of these elements. Gas bubbles, entrapped in the ingot, were reduced in size from a range of 5 to 25 mm. to 0.5 to 2 mm. Also, they were

Fig. 1 – Three Methods for Inducing Ultrasonic Waves in Molten Metal. Reading left to right, the magnetostrictive transducer is at the bottom, at the top, and in the wall of the ingot mold. Ultrasonic treatment reduced both oxygen and nitrogen in rimming steel



concentrated near the ingot surface, rather than through 50% of the ingot cross section as before.

The ultrasonically treated ingots were rolled into sheet, aged three months, and mechanically worked to a 35 to 40% reduction. The reject rate of the untreated metal (due to cracks, seams and the like) was 57%, while none of the 100 samples of ultrasonically treated steel were rejected. Grain size was reduced and intergranular nitride network was eliminated; mechanical properties are given in Table I.

Table I – Mechanical Properties of Ultrasonically Treated Ingots

Material	Ultimate Tensile Strength		Elongation	
	Untreated	Treated	Untreated	Treated
Rimming steel*	49,500 psi.	66,600 psi.	30%	50%
Machinery steel†	63,800	107,000	15	20
Gray iron	25,600	80,000	0	5

*0.08% C, 0.35% Mn.
†0.45% C, 0.30% Si, 0.65% Mn.

The Central Research Institute for Ferrous Metallurgy has been studying the effects of ultrasound upon solidification of several types of alloy steels and cast irons. In all experiments, grain sizes were reduced, and dendritic structures either disappeared or were substantially lessened. Mechanical properties of 25% Cr, 20% Ni steel and 27% Cr steel – both types are prone to coarse grain – were improved. For the latter, elongation increased three times, reduction of area, seven times, and impact strength, 2.5 times. Tensile strength, elongation and ductility rose 1.2 to 1.6 times for 25% Cr, 20% Ni steel. These improvements were attributed to four to five-fold reduction in the macrograin size; nonmetallic inclusions were also dispersed uniformly throughout the ingot.

The Russian researchers theorize that these advantages result from the cavitation effect of the ultrasonic waves in the molten metal. These waves create very high instantaneous pressure peaks and shatter the dendrites as they grow. Then, the particles disperse to provide nucleation centers for the growth of new crystals.

The vibrations also break up and disperse nonmetallic inclusions, and stir the melt; both actions contribute to the chemical and structural uniformity of the ingot.

Fewer Cracks in Aluminum Alloys

Hot shrinkage cracking of two aluminum alloys (the wrought alloy contained 6% Zn, 2.3% Mg, 1.7% Cu, 0.4% Mn and 0.2% Cr, while the casting alloy had 4.5% Cu and 1.2% Si) was reduced by vibrating the mold in the 50 to 800-cycle per sec. range. For the experiment, the metal was poured into a cored mold and vibrated at various frequencies. When frequencies were plotted against crack susceptibility (defined as the ratio of the longest crack to the perimeter of the casting), the "hot cracking susceptibility" decreased almost linearly with the rise in cycles per sec. Minimum frequency depended upon height; it was 160 cycles for a 1.8-in. casting, and 90 cycles for the 1.14-in. casting.

Low frequencies reduced or eliminated centerline porosity and secondary shrinkage pipe in aluminum alloy castings containing 5% Si, 0.3% Zn, 5.3% Cu, 0.45% Mg, 0.5% Fe, 0.6% Mn and 0.05% Ni. After pouring molten metal into the metal, graphite, and sand molds, the molds were placed on an eccentrically vibrated table. In the illustrated setup (Fig. 2), the right side of the table vibrates vertically while the left side is stationary and rotates around a hinge. Thus, the vibration amplitude

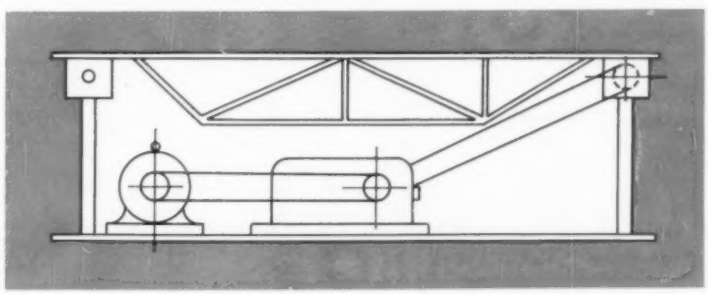


Fig. 2 – Vibrating Table Used for Experiments in Eliminating Secondary Pipe. The table moves up and down at the right (through the action of an eccentric), but is hinged at the left. Thus, the magnitude of the vibrations depends upon the position of the mold on the table

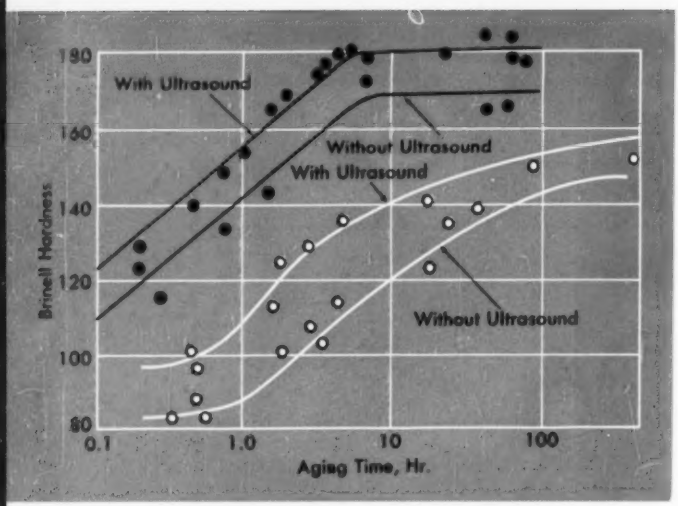


Fig. 3 – Ultrasonic Aging of a Typical Aluminum Alloy. Vibrations raised hardnesses and reduced times of aging at room and elevated temperatures. White curves represent aging at room temperature; black curves represent aging at 125° C. (250° F.)

is determined by the location of the mold on the table. No improvement was observed when the molds were rigidly attached to the table. However, when molds were freely placed on the table (held by a special hinge), secondary pipe was greatly decreased or eliminated.

At the Byelorussian Academy of Sciences, Gorsky and Efremov have shown that precipitation from solid solutions, which accounts for aging, can be accelerated and intensified ultrasonically. While it takes 50 to 90 hr. to age duralumin (4.5% Cu, 0.8% Mg, 0.5% Si, balance Al) naturally, the time can be cut to 0.7 to 1.5 hr. by vibrating at 30 kc. and 250 w. per sq.in. intensity. Hardness also rose from Brinell 60 to 100. When several other aluminum aging alloys were also investigated, similar results were obtained. To illustrate, aging times of an alloy containing 4.5% Cu, 0.8% Mg, 1.5% Si and one with 0.5% Mg, 0.5% Si were reduced 75 to 80-fold, and a 50% increase in hardness (from Brinell 42 to 62) was also noted.

Pogodina and Eskin investigated the effect of ultrasonics upon natural and artificial aging of aluminum alloy B-95 (this alloy has 5 to 7% Zn, 1.8 to 2.8% Mg, 1.4 to 2% Cu, 0.2 to 0.6% Mn, 0.1 to 0.25% Cr, and 0.5% max. each Fe and Si). After solution treating at 470° C. (880° F.), specimens were placed in an oil bath and "sounded" at 125° C. (250° F.) and at room temperature. The progress of aging is shown in Fig. 3. As can be seen, ultrasonic aging at room temperature for 5 hr. is equivalent to 60 hr. of conventional natural aging – a 12-fold acceleration. The hardness of the "sounded" specimen, after 12 hr. of aging, was Brinell 134, while that of the untreated pieces was 113. Artificial aging at 250° F. is speeded 50-fold, and final hardness is increased from Brinell 163 (without ultrasonics) to 180.

Aging Heat Resistant Alloys

According to Goodtsoff and Gavze, an alloy with 60% Cr, 15% Mo and 25% Fe reaches a hardness of Rockwell C-87 to 93 in 1 hr. (instead of the usual 50 hr.) when vibrated ultrasonically at 700 to 760° C. (1300 to 1400° F.). The same treatment, however, had no measurable effect on Elinvar-type alloys. They also concluded that the intensity, rather than the frequency, of ultrasonic waves determined the effect upon aging processes.

Relying upon this conclusion, researchers at the Leningrad Air Force Engineering Academy constructed a device which would ultrasonically age a heat resistant alloy EI 437 b (0.05% C, 0.23% Mn, 20.5% Cr, balance Ni). Experiments were made at 700, 750 and 800° C. (1300, 1380 and 1470° F.) and 20 to 25 kc. These treatments accelerated aging rates from 15 to 50 times, depending upon temperature and intensity. Hardnesses were also higher.

When Pogodin-Alexeev, professor at the Bauman Polytechnic Institute at Moscow, ultrasonically aged (at 21.5 kc. and 5 kw.) Nimonic-type alloys at 700 and 750° C. (1300

Table II – Effect of Ultrasonics on Carburizing Case Depth

Carburizing Time*	Armco Iron		Steel†	
	Without Ultrasound	With Ultrasound	Without Ultrasound	With Ultrasound
¼ hr.	0.004 in.	0.014 in.	0.004 in.	0.008
1	0.011	0.021	0.009	0.017
2	0.018	0.033	0.015	0.027
3	0.024	0.046	0.020	0.034
4	0.031	0.055	—	—

*Temperature, 1000° C. (1830° F.)
†0.12% C, 0.75% Cr, 3.00% Ni

and 1380° F.), he found that hardness increased, impact strength decreased and aging time was cut in half. Also the effect of ultrasonics on aging depended upon the magnitude of tensile stresses* produced in the specimen.

Heat Treating Steel

In an experiment to determine the effect of ultrasonics upon the heating rate of a nickel steel with low carbon and chromium, samples with attached thermocouples were heated in an oil bath at 150° C. (300° F.). With temperatures recorded every 30 sec., a vibration of 1 megacycle at 10.3 w. per sq.in. decreased the time required to reach temperature from 9 to 6 min.

Armco iron aged more rapidly when the metal was "sounded" at 100° C. (212° F.). Primary hardening occurs after 6 to 7 min., while secondary hardening is absent; this apparently indicates that both occur simultaneously.

The effects of ultrasonic waves upon changes in metals and alloys in the solid state lead Russian scientists to believe that they aid transformation from a thermodynamically unstable to a stable state. The researchers also theorize that high-intensity vibrations affect lattice parameters, thereby helping these changes.

Case Carburizing

Pogodina-Alexeeva determined the effects of magnetostrictive vibration (21.5 kc., 5 kw.) on pack carburizing of Armco iron and on steel containing 0.12% C, 0.75% Cr and 3.00% Ni. These metals were carburized (in a mixture of 75% wood coke and 25% Na_2CO_3) at 1000°C. (1830° F.) for periods varying from 15 min. to 4 hr. Depths of the carburized layers for each treatment are summarized in Table II.

As this table shows, when these metals were ultrasonically treated during carburizing, the case depth was twice that of specimens which were merely carburized. To look at this from another angle, the time required to achieve the required carbon content (or a given depth of case), was reduced about 50% when ultrasonics were used. Pogodina-Alexeeva also found that the effect of ultrasound increased with intensity. Thus, when intensity was increased 1.5 times, the case depth of Armco iron carburized at 1000° C. (1830° F.) for 2 hr. rose from 0.83 mm. to 1.15 mm. – almost 1.5 times.

*To determine this, he measured stresses induced in ultrasonically treated specimens and correlated their magnitude with other properties and ultrasonic parameters.

In Electroplating

It is well known that zinc and cadmium plating (used for corrosion protection) often embrittle the steel being plated. This occurs because hydrogen diffuses into steel as the metal is being deposited. With the idea that ultrasonic treatment might aid plating, the Russians made some appropriate tests. When they subjected an electrolytic bath (used in plating carbon steel for springs) to an ultrasonic vibration of 16 kc., 16 watts per sq.in., they found that the treatment improved spring ductility greatly. In addition, the degreasing rate was increased three to four times and the etching rate three to five times.

These improvements were attributed to the action of the cavitation bubbles which formed at the metal surface during ultrasonic treatment. According to the researchers, these bubbles burst at the surface to form a vacuum, and hydrogen from the metal filled this vacuum. Vibrations also caused intensive mixing of electrolyte, degreasing and etching solutions.

Ultrasonic Welding

The Russians report other interesting applications of ultrasonic vibration, particularly in welding. Experiments have shown that ultrasonic vibration of a solidifying weld metal pool refines grain size, reduces gas content and improves the mechanical properties of the weld metal. Low frequency vibration of the weld pool increases impact properties because of a partial breaking up of large dendrites into finer and differently oriented crystals.

Several methods of introducing vibration into the metal bath have been investigated. The problem is simpler for large pools, and for this reason one of the earlier applications was in electroslag welding. For other welding methods, vibrations are transmitted by a supplemental consumable wire fed through specially developed apparatus. Aluminum and austenitic stainless are among metals welded in this way.

Aluminum (99.5%) and Cu-Mg-Mn-Al and Mg-Al alloys have been ultrasonically seam and spot welded in thicknesses up to 1.5 mm. Several ultrasonic welding machines have been developed and research on the effect of welding on the properties of the joints is under way.

In addition, work has been done on the effect of ultrasonics on mechanical working. It has been found that vibrational plastic deformation contributes to working of "difficult" metals and improves their properties.

International Figures in the History of the Man-Made Metal Plutonium

An outline of work done in various laboratories in the United States, Canada, England, France and Russia, giving credit to the principal scientists and metallurgists.
(A-general, A2; Pu)

*By ARTHUR S. COFFINBERRY**

PLUTONIUM WAS DISCOVERED early in 1941 by Glenn T. Seaborg and associates at the Radiation Laboratory of the University of California. During the remainder of that year and in early 1942, its chemical properties were studied at Berkeley on the tracer scale by A. C. Wahl and others in the department of chemistry. Meanwhile, continuing investigations at the Radiation Laboratory of the nuclear properties of plutonium established the great value of Pu^{239} as a fissionable isotope, capable of releasing enormous amounts of nuclear energy through a chain reaction, and led to the inauguration of the wartime Plutonium Project having as objectives the large-scale production of Pu^{239} and its possible use in a nuclear weapon.

The well-known Smyth Report describes at some length the administrative, scientific and technical programs which resulted in a chain reaction in natural uranium, and thereby demonstrated the possibility for large-scale production of byproduct plutonium in such a reactor. The solution of this problem was the primary objective of the "Metallurgical Laboratory" established at the University of Chicago in 1942. A further objective was the chemical separation of plutonium from the other materials present in irradiated uranium. Hence the continuation of research on the chemistry of plutonium that was undertaken at the Metallurgical Laboratory was directed toward the development of a satisfactory separation method.

At the beginning of this research, tracer techniques still had to be used, but, as the result of a decision to increase appreciably the amount of plutonium then being produced in cyclotrons, B. B. Cunningham was able to perform the first of what have been called "ultra-microscale" experiments with plutonium. Moreover, as a consequence of his development of "ultra-microchemical" techniques, he and L. B. Werner were able in September of 1942 to isolate and weigh a compound of pure plutonium (2.77 micrograms of PuO_2).

The quantities of cyclotron-produced plutonium which were available were sufficient to start metallurgical investigations at the Metallurgical Laboratory in Chicago before the end of 1943, when reactor-produced plutonium began to be extracted from the fuel elements of the pile at Clinton (now Oak Ridge, Tenn.). During 1943, the first reductions of plutonium to metal were made at the Metallurgical Laboratory in Chicago by H. L. Baumbach, S. Fried and associates, who employed micrometallurgical methods that were unprecedented in the Western World. During 1944, as soon as plutonium from the Clinton Works became available in gram quantities, the major effort in metallurgical research on plutonium was transferred to Los Alamos. The "large-scale" production of

*Until recently, director of work on plutonium metallurgy at Los Alamos Laboratory, U. S. Atomic Energy Commission. Now at Centre d'Études pour les Applications de l'Énergie Nucléaire at Mol, near Brussels, Belgium.

Eric Randolph Jette Joined Los Alamos Laboratory in 1944 and Directed Work on the Metallurgy of Plutonium. He became leader of the chemical and metallurgical division in 1946, resigning in 1956 to become staff consultant in Union Carbide Corp. (Research Administration)

plutonium metal began at Los Alamos in February 1945, after receipt of the first shipment of the product of the Hanford (Wash.) reactors and their associated chemical processing plant.

During the war years, the metallurgy of plutonium was studied at Los Alamos within the Chemistry-Metallurgy Div., which was administered jointly by Joseph W. Kennedy and Cyril Stanley Smith. At that time the investigations were carried only as far as was deemed necessary for utilization of the metal as a component in nuclear weapons. Soon after the conclusion of hostilities, however, plans were made for the construction of an experimental fast reactor in which plutonium would be used as the fuel. This project led to the first plutonium-fueled reactor dubbed "Clementine", which was brought to full power (only 25 kw., however) in March of 1949.

The metallurgical knowledge utilized in fabricating the Clementine fuel elements did not extend beyond what had been learned during the war, and consequently did not provide a type of fuel suitable for commercial power reactors. It was not until 1949 that serious attention was given at Los Alamos to the study of plutonium alloys which might be useful in solid fuel elements at the high temperatures required in industrial power reactors. Intensive investigation of liquid plutonium fuel alloys did not begin until even later, in 1955.

The wartime research at Los Alamos on the physical metallurgy of plutonium was directed by Eric R. Jette, who in 1946 succeeded both Kennedy and Smith as the division leader for chemistry and metallurgy. Throughout most of the period since then, Arthur S. Coffinberry has been in charge of the plutonium physical metallurgy group originated by Jette, although F. W. Schonfeld has recently become its group leader. Another recent development has been the transfer to the supervision of Robert D. Fowler of those groups within the former Chemistry-Metallurgy Div. that are concerned primarily with the more fundamental aspects of both chemical and metallurgical research. These groups, which include the plutonium physical metallurgy group, now (in mid-1960) comprise a new division under the leadership of Fowler, the remainder of the former Chemistry-Metallurgy Div. being directed by Richard D. Baker.

Another postwar development was the evolution of the Argonne National Laboratory (A.N.L.) as the successor to the Metallurgical Laboratory at the University of Chicago. From its inception the primary responsibility of A.N.L. has been reactor development, but initially the types of reactors designed and constructed there, and at its Arco, Idaho, extension, employed only uranium as the fissile material. However, the inevitability of using plutonium as a fuel for power reactors led in 1954 to the installation at A.N.L. of a small laboratory for plutonium metallurgical research. To this modest beginning has since been added an impressive plant for the fabrication of plutonium-alloy

Cyril Stanley Smith Was One of the Earliest Scientists to Reach Los Alamos (March 1943) and Stayed There Until the War's End. He is a real pioneer in plutonium metallurgy, and directed metallurgical work of wide variety, including the shaping of the plutonium core of the first atomic bomb (Alamogordo, July 1945)

O. J. C. Runnalls Is a Canadian Pioneer in the Study of Plutonium for Peaceful Purposes, Working Since 1951 at the Chalk River Project of Atomic Energy of Canada Limited Near Ottawa. He has intently studied plutonium alloys, primarily for use as reactor elements and to "spike" natural uranium fuel

fuel elements, and a much larger metallurgical research laboratory for both plutonium and uranium is now being constructed there. The over-all supervision of these projects is the responsibility of Frank G. Foote; Arthur B. Shuck and L. R. Kelman have been in charge of developing the detailed plans for the fuel element facility and research laboratory, respectively.

Work of the Chemistry and Metallurgy Div. of the wartime Los Alamos Laboratory is dismissed in the famous Smyth Report in exactly 106 words, in which no mention at all is made of any work on plutonium, the man-made fissionable metal used in the first atomic bomb at Alamogordo, N. M., exploded in July of 1945. Cyril S. Smith filled this gap, as well as security regulations at the time would permit, in his article "Metallurgy at Los Alamos, 1943-1945" in *Metal Progress* for May 1954. We at American Society for Metals are also proud that the first public conference devoted exclusively to plutonium metallurgy was held under joint sponsorship with the U. S. Atomic Energy Commission at the Second World Metallurgical Congress in Chicago in November 1957. Arthur S. Coffinberry organized this program, and his introductory remarks are now brought up to date in this article, wherein credit is given to many persons both here and abroad who have intently studied this most extraordinary metal.

At present, research in the field of plutonium metallurgy leading to publishable results is being done in the United States at only two other A.E.C. installations, the Hanford Atomic Products Operation at Richland, Wash., and the Mound Laboratory of the Monsanto Chemical Co. at Miamisburg, Ohio. Initially, the reduction of plutonium to metal was not a step included in the processing done at Hanford. In recent years, however, and especially since the development of a plutonium-fueled power-reactor concept has become a project there, both the extractive and the physical metallurgy of plutonium have become major activities at Hanford, O. J. Wick being in charge.

Since 1956, when metallurgical work with plutonium at the Mound Laboratory began, this work has consisted primarily of the production of neutron sources containing a plutonium-beryllium alloy. More recently, however, this laboratory has extended its program in plutonium metallurgy to include the investigation of several problems pertinent to the liquid plutonium reactor (LAMPRE) project at Los Alamos Laboratory.

Although not equipped to do metallurgical research on plutonium, several other American laboratories engaged in the development of power reactor concepts have devoted extensive study to the potentialities of plutonium as a

E. Grison Organized the First French Team (1955) to Study Plutonium. At present he is head of the plutonium department of the French "A.E.C."—Commissariat a l'Énergie Atomique

From 1946 to 1959 H. M. Finniston Has Directed the Metallurgical Work at the Research Establishment of the U. K. Atomic Energy Authority at Harwell, Wherein Work on Plutonium Has Played an Important Part. He is now in charge of the Nuclear Research Center of Messrs. C. A. Parsons & Co. Ltd., at Newcastle upon Tyne

reactor fuel. As early as 1950, T. M. Snyder, A. U. Seybolt and others at the Knolls Atomic Power Laboratory (K.A.P.L.) considered ways in which plutonium could be made the fuel in a power-breeder reactor, and they requested the plutonium metallurgy group of Los Alamos to perform certain experiments pertinent to their design concept. More recently the interest at K.A.P.L. in the uses of plutonium for fuel has been directed toward a cermet-type of element in which plutonium is combined with uranium in an oxide phase.

In 1952 Los Alamos received a second request to undertake a metallurgical investigation in the interest of reactor development at another laboratory. This task was to determine the solubility of plutonium in molten bismuth, information needed by D. H. Gurinsky and associates at the Brookhaven National Laboratory if they were to adopt their liquid-metal-fuel reactor concept to operation with plutonium.

In the United States the only cooperative group of power and related industries which is actively promoting fast rather than thermal reactors for generating electric power is Atomic Power Development Associates of Detroit, Mich. Although their Enrico Fermi reactor, now under construction, will initially be fueled with enriched uranium, the engineers are fully cognizant of the advantages of using plutonium as the logical fuel for a fast reactor. A. P. Donnell, R. E. L. Stanford, and others on this project have given particular attention to the use of a plutonium fuel in fluid form, either liquid or paste.

Great Britain and Canada – During the war, the beginnings of British activities directed toward the military potentialities of nuclear energy were centered mainly in the Cavendish Laboratory at Cambridge University, although production of uranium metal and hexafluoride was undertaken by Imperial Chemical Industries in the Liverpool area in 1941. However, because of the danger of enemy action, and in order to associate the British and American efforts more closely, the British nuclear research program was transferred to Montreal in Canada in 1943. Growth of the Montreal project led, in turn, to the establishment in 1944 of a permanent reactor and chemical processing site at Chalk River, Ont. Construction at this site of the N.R.X. reactor produced plutonium in October of 1947 and later led to a study of plutonium alloys by O. J. C. Runnalls that was oriented primarily toward their possible use as "spike" elements to be added to the natural uranium fuel of the N.R.X. core.

Meanwhile, the end of the war had made it possible to repatriate the United Kingdom's major program in nuclear research, and this resulted in the creation of several British national laboratories such as the Atomic Energy Research Establishment (A.E.R.E.) in 1946 at Harwell and the Atomic Weapons Research Estab-

Arthur S. Coffinberry (Right) Shakes Hands With Andrey A. Bochvar, Soviet Metallurgist Long Associated With the Moscow Institute of Nonferrous Metals and With the Moscow Institute for Advanced Studies, Where Plutonium Has Been Investigated During the Last Decade. Bochvar was visiting Los Alamos Laboratory late in 1959, where Coffinberry (author of the present article) has studied the physical metallurgy of plutonium since the mid-1940's, in the later years concentrating on liquid fuels containing plutonium. Quite recently he has moved to the Centre d'Études pour les Applications de l'Énergie Nucléaire at Mol, near Brussels, Belgium, to work on the metallurgical problems of solid fuel elements

lishment (A.W.R.E.) in 1951 at Aldermaston. From their inception, plutonium metallurgy has played a prominent role in the research programs of these laboratories. At A.E.R.E. the plutonium physical metallurgy section is supervised by M. B. Waldron, with H. M. Finniston (until recently) providing over-all metallurgical direction. At A.W.R.E. a corresponding group reports to A. E. Kay, with W. B. H. Lord in general charge of metallurgical activities.

Although the operation of plutonium-producing reactors in Great Britain is administered by the Industrial Group of the Atomic Energy Authority, research laboratories for metallurgical studies of plutonium have not existed within this widespread organization until quite recently. Currently coming into operation at Dounreay, Scotland, is a laboratory in which, along with other metallurgical investigations, those pertinent to plutonium fueling of the Dounreay fast reactor will be undertaken.

France – In France, plutonium metallurgy began in January of 1956 when several grams of metal extracted from the fuel slugs of the EL-2 reactor at Saclay were transferred to the plutonium laboratory at Fontenay-aux-Roses. This laboratory was established by renovating and adapting the venerable Fort de Chatillon, built on the outskirts of Paris soon after the war of 1870. At this laboratory, now a part of the Centre d'Études Nucléaires de Fontenay-aux-Roses, research on the physical metallurgy of plutonium, and especially on its applications to power reactors, is being pursued by a group of metallurgists and physical chemists under the direction of E. Grison.

Russia – The first account of work done in Russia on plutonim metal and its alloys was presented at a meeting in Moscow, July 1955, by the U.S.S.R. Academy of Sciences on the peaceful uses of atomic energy. Judging from the quantity and variety of results reported at that time it seems likely that the work was begun well in advance of the date of the meeting. Moreover, because microscale methods of metallurgical research had been devised by them previous to World War II, the availability of these techniques enabled the Russian plutonium metallurgists to begin their work as soon as only microgram amounts of the man-made metal had been produced in the Soviet reactors.

S. T. Konobeevsky was the author of this first Russian paper, but it was acknowledged therein that the data represented the combined contributions of a group of scientists. Among the authors of subsequent Russian papers on plutonium and its alloys the names of both Konobeevsky and A. A. Bochvar appear prominently, and from this circumstance it might be concluded that research in the field of plutonium physical metallurgy is being pursued only at the Moscow Institute of Nonferrous Metals, an institution with which Konobeevsky and Bochvar have long been associated. However, in conversations with Soviet metallurgists at the Second United Nation's International Conference on the Peaceful Uses of Atomic Energy (Geneva, 1958) it was learned that plutonium metallurgical research was at that time being conducted by more than 100 graduate scientists at some eight different laboratories under the control of the Moscow Institute for Advanced Studies (with which, presumably, Konobeevsky, Bochvar and their co-workers are associated).

Large Steel Castings for Heavy Duty

*By HEINZ W. BALSTER**

Basic electric furnaces with capacity over 25 tons and with induction stirring are used for alloy steels. A Cr-Mo-V analysis similar to Type 316 has been widely used for high-temperature service, and 13% Cr steel is favored for corrosion resistance. Welding of simple shapes into complex assemblies is common practice. (E-general; ST, AY, SS)

IN GERMANY, just as in the United States, the capacity of modern machinery and equipment has been increased year after year and at the same time improved efficiency and lower production costs have been demanded. To meet these requirements, steel castings are playing quite an important part. The essential requirement for economical design (strength matched to stresses in each region of a structural part) can generally be achieved only in a casting. Producing sound castings with improved quality, simultaneously reducing their cost, has always been the aim of German research and it will doubtless continue to be in the future.

Steel Castings for Machinery

In Germany the largest steel castings for roll housings have reached a weight of 275 tons, which meant that about 400 tons of liquid steel had to be available.

Heavy and intricate unalloyed steel castings are being used for highly stressed parts in mechanical engineering. As a typical example may be mentioned a yoke for a Y-pipe recently manufactured for the high-pressure penstock at the Rosshaupten hydro-electric power plant in Bavaria. The penstock drops 65 ft., and water rushes through it at a speed of 20 miles per hr. The yoke of nonaging steel, analyzing 0.18% C, 0.36 Si, 0.75 Mn, 0.02 P and 0.025 S, had been cast in three parts which were machined and welded together in the shop (Fig. 1). It was necessary to preheat the parts before welding; they were then stress-relieved.

This is an example of the fact that joints can be welded even in the largest sections without reducing the quality of the steel casting. Since this combination of casting and welding is often the most economical, new applications of steel castings have been discovered, particularly during the last few years, thus giving a fresh impetus to the foundry business.

Heat Resistant Parts

Improved castings for high-temperature service can be considered a recent example of progress in quality. Through systematic metallurgical research, analyses and techniques are now able to meet advanced requirements of steam turbines. Twenty years ago, steam entering the turbine generaliy had a temperature of about 840° F., while today the new equipment operates at about 1065° F. with pressures correspondingly increased. The time required to start a turbine up from cold used to be about 2½ hr.; this has been cut in half.

To resist the highest stresses in this particular service, the 13% Cr-Mo-V casting which contains 0.20 to 0.25% C, 0.15 to 0.40% Si, 0.4 to 0.7% Mn, 11.5 to 12.5% Cr, 0.4 to 0.8% Ni, 1.2 to 1.4% Mo and 0.25 to 0.35% V has proved to be the best. The content of carbon, silicon and vanadium must be so proportioned that no delta ferrite forms in the microstructure. Owing to its resistance to scaling, this pearlitic steel casting stands operating temperatures up to 1125° F.

In the fundamental studies leading to the

*Director of Development and Research, Ruhrstahl A. G., Düsseldorf, West Germany.

Fig. 1 – 70-Ton Cast Steel Yoke for Hydro-Electric Penstock, Three Sections, Welded Together. (Ruhrstahl, Henrichshutte)

above achievement it was particularly important to study creep and stability for extended times. Tests lasting from 20,000 to 60,000 hr. were common – even 100,000 hr. – at the highest anticipated steam temperatures (1380° F.).

Casting and molding techniques have also been improved. For example, in casting a steam turbine casing chaplets are no longer used, because these inhomogeneous parts easily cause porosities. Today the main core is held in position by several smaller cores which leave small openings in the wall, later to be closed by welding with electrodes depositing the same analysis as the main body.

Nondestructive testing is widely used on such high-temperature steel castings as the above. It goes without saying that core openings which have been closed by welding are submitted to X-ray examination. This also applies to tubes, nozzles and sockets, welded on (Fig. 2). Ultrasonic testing is also used to a considerable extent for examining turbine steel castings.

Valves, jet segments, turbine casings, guide wheels, collectors, and flanges and connectors for tubing – all subject to temperatures exceeding 1125° F. – are made exclusively of austenitic Cr-Ni-Mo steels, with or without columbium-tantalum as a stabilizing additive. The analyses used in Germany approximate the wrought steels, Types 305 and 316, used in the United States, rather than any of the designations of the American Casting Institute: 15 to 17% Cr, 10 to 14% Ni, 1 to 3% Mo, without or with 0.3 to 0.5 Cb (or the natural mixture of Cb and Ta).

The stress-to-rupture after 100,000 hr. and 1% elongation is 6400 psi. for Steel I (unstabilized) and 7125 psi. for Steel II (stabilized). If either of these steels are exposed to the operating temperature for a long time, they will embrittle (lose tensile ductility when tested at room temperature) due to segregation within the austenitic groundmass.

Essential developmental work must still be done before we can produce austenitic steel castings which have a good stress-to-rupture value after a specific number of hours, little trend toward embrittlement, a good initial notch toughness, and weldability without susceptibility to cracking alongside the joint.

Stainless and Acid Resisting Castings

For parts which must resist fresh or salt water, castings with 13% Cr are very satisfactory. A decade ago the largest finished product weighed about 22 tons. Modern water-power stations are always requiring larger and larger units – for example, larger rotors for Francis and Pelton turbines – and foundries serving this industry must increase their molding and melting capacities to be in the position to cast

rotors weighing up to about 75 tons, finished.

In Germany, chamotte is used as molding material; cores are also being made from it. Since the molten steel rapidly forms insoluble oxide films, it must be quickly poured. Appropriate design of the gates and runners permits the steel to rise freely during pouring.

Foundry Practice

Unalloyed and low-alloyed grades of steel are almost always made in basic openhearth furnaces. As indicated above, the largest castings now require up to 450 tons of liquid steel. Of course this can only exist where the steel melting furnaces are constantly supplying metal for other divisions – primarily making ingots for rolling mills. In Germany, large steel castings are therefore a byproduct of the large integrated steelworks.

Up to a few years ago the unit capacity of our electric arc furnaces was limited to about 40 tons. More recently larger ones (110 tons of liquid steel) have been built to produce casting grades of highest purity and with close control of chemical analysis – a matter which has always been strictly observed. Almost all electric arc furnaces have basic linings.

Induction melting furnaces using medium frequency have given quite satisfactory results when the higher alloyed steels or nickel-base alloys are needed in steady stream and small quantities of fill the molds. A definite disadvantage of this type of furnace (which has either acid or basic lining) is the difficult slagging practice. Therefore one must charge expensive pure ingredients, and this increases the cost.

Application of Modern Methods

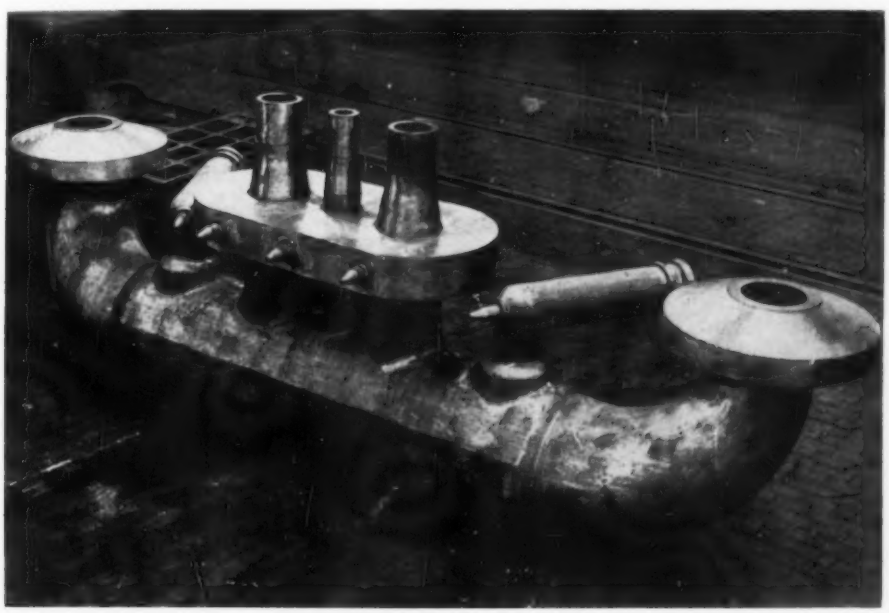
Inductive stirring of liquid steel has these advantages, especially for large furnaces:

1. Uniform temperature throughout the melt.
2. Complete and uniform solution of all alloying constituents.
3. Extremely low content of sulphur in the finished metal.
4. Low content of nonmetallic inclusions.

Complete removal of slag in the furnace also plays an essential part in the melting of high-quality electric steels for castings. The high-alloy steels, such as the 13% Cr steel mentioned above, are always stirred, especially if large castings are to be poured.

Vacuum treatment of liquid steel in the ladle is an important new innovation. Among the several vacuum treatments we find that the Ruhrstahl-Heraeus continuous flow vacuum degassing process has great promise for the steel foundry. It consists in sucking liquid steel from

Fig. 2 – Valve Chamber for High-Pressure Steam Turbine. Several weldments of 13% Cr-Mo-V steel form a unit weighing 5.25 tons. (Ruhrstahl, Oberkassel Steel Foundry)



the ladle into an evacuated vessel, where the steel is degassed quickly in a finely dispersed form and then returned to the ladle below.*

Numerous applications of this degassing process have not as yet been exhaustively analyzed. The excellent results obtained on steel for heavy forging ingots will no doubt be achieved for large steel castings. The degassed steel can be poured in an exceptionally quiet state even at very low temperatures – a factor which has great influence on the formation of primary dendrites and on the prevention of segregation.

Byproduct Ingots or Billets – If the foundry is not a division of a large integrated steel works, it will be difficult to utilize the available liquid steel to good advantage. Generally there will be no option but to adjust the melting rate proportionately to the amount required for the molds which can be prepared, and the efficiency of the furnaces may thereby be greatly reduced, thus necessarily increasing costs.

To assure the furnaces a minimum steady load and consequently improve the economics, J. Hofmaier has suggested that a continuous steel casting machine be added to the steel melting plant. (See *Stahl und Eisen, Vol. 77*, 1957, p. 68.) This could absorb that quantity of liquid steel which would be available beyond the needs of the foundry.

Calculations show that the economic efficiency of such an arrangement will be improved, especially where alloy steels can be poured as continuous castings. It is, however, necessary that a certain minimum quantity of steel be available (dependent on the size of the casting machine) for conversion into billets, blooms, round billets or slabs.†

Molding Materials and Techniques – All molds for large steel castings, as well as the cores, have always been made of chamotte and then baked. Its advantages are manifold: Blind scabbing is prevented; chamotte resists wash by hot metals; gating of molds is considerably simplified, since clay tubes must line gates and runners in sand molds. Chamotte molds can be poured from the top, which is frequently necessary to control solidification.

One disadvantage is that chamotte costs four or five times as much as a mixture of natural molding sands, even though part of it can be reclaimed for reuse. For this reason we are trying to substitute synthetic sands for chamotte. Furthermore, chamotte batches can not be handled by sand slingers, and the necessary manual work increases costs correspondingly.

Thorough research into the properties and uses of bentonite and the further development of synthetic molding sands may permit us eventually to make castings of even larger sizes and thicker walls. Further research is necessary to replace the empirical rules for locating risers and runners by scientific knowledge about that branch of the foundry art. Even so, modern steel foundries in Germany have made good use of the available scientific data, and can now produce castings of better quality than when relying on empirical values. However, the yield of castings and the economics of the steel foundries could simultaneously be augmented by further systematic experimentation.

Details – In comparison with American steel foundries, it is immediately apparent that German firms pour steel at slower speed. However, for some years we have been pouring large castings, especially, at faster rates. One great advantage is that the liquid steel attacks the molding material much less. Cold shuts also can be prevented almost certainly.

Precisely calculated chills have been inserted into the molds with great success to control solidification of the liquid steel. This technique is founded on scientific knowledge and has proved quite satisfactory even for difficult items, such as heavy press cylinders, and cast crankshafts requiring complete soundness even in especially large sections.

Welding

In view of the present excellent techniques, welding has to be considered as one of the production processes in the steel foundry. Intricate and difficult castings can scarcely be made without using chaplets or providing some openings through the walls. Obviously these chaplets or openings must be carefully removed or filled. The only way to do it is by welding.

Minor flaws in steel castings, detected by improved nondestructive investigations, can usually be mended by welding.

According to the latest edition of the German standard DIN 17245, "High-Temperature Steel

*See discussion by H. W. Balster (p. 191, *Proceedings* of the Electric Furnace Steel Committee, A.I.M.E., 1958) of paper by C. W. Finkl on "Experiences With Ladle Degassing".

†EDITOR'S FOOTNOTE – Mr. Balster has written an article for publication in *Metal Progress* early in 1961 on the desirability of casting steel ingots by "direct chill" methods and equipment, similar to that universally used in the aluminum industry.

Castings", welding is expressly permitted because parts of intricate shape cannot be manufactured otherwise. Careful and clean preparation of the metal at the joints is specified, as well as a nondestructive test of the weld after its completion.

It is becoming a common practice to subdivide the larger and more difficult castings into simpler and smaller parts. The molds of the corresponding pieces are prepared, the parts cast, and finally welded together to form a single intricate structural unit.

Most welding is still done by hand-controlled arc, using coated electrodes. Much study has been given to metallurgical processes occurring in the arc and to the material used as electrode coatings. This has led to a considerable improvement of the quality of the joint and of the welding speeds.

When welding those alloyed steel grades for which neither an addition nor a subtraction of carbon can be tolerated, inert gas welding methods have shown good results. The following processes are in use: *(a)* Employing a tungsten electrode and argon as a protective gas ("argon arc"). To stabilize the arc the tungsten electrodes are now being alloyed with thorium. *(b)* Using a consumable electrode under protective inert gas ("Sigma"), a process which has the advantages that there is little distortion of the workpiece and small spatter.

Submerged arc and those other welding processes which use a blanket powder to protect the molten puddle have so far found little application in German steel foundries.

While automatic welding is not used nearly as widely as manual, the "net electrode" has proved satisfactory in many foundries. The oxide-lime coating on this electrode is pressed into the interstices of a network made of thin steel wires which surround the core wire in right-hand and left-hand winding.* These thin steel wires conduct the electric current from the copper contact jaws of the automatic welding machine to the end of the core wire, the arc. These coated electrodes are flexible enough so they can be coiled almost endlessly for the automatic welding machines.

Testing

The immense developments in the steel foundry field have promoted an expansion of plant laboratories and research centers in Germany. A great many plants have the most modern equipment at their disposal.

For chemical analysis many spectrographs are in use. Satisfaction with this equipment in the large integrated steelworks has also induced the quality-steel foundries to install the automatic spectrograph, particularly for the control of alloy steel and complex alloy grades, since this greatly facilitates the accuracy with which the close specifications are met, and economizes on expensive alloying elements.

In mechanical testing, particularly of high-temperature steel grades, long-time tests lasting 20,000 to 60,000 hr. (sometimes up to 100,000 hr.) at the highest practically-usable temperatures are essential. Such equipment is in operation at numerous foundries.

Nondestructive testing by gamma and X-rays, as well as magnetic crack-testing and ultrasonic apparatus, becomes of ever greater importance. Particularly in the last few years the research departments of the German steel foundries have been equipped with apparatus of latest design. High-duty steel castings for heavy machinery, for power stations, oil refineries and the chemical industry are always subjected to nondestructive test and are only shipped if they prove to be sound.

Outlook

Even though steel castings were first made more than a hundred years ago, their quality has been continually increasing and still can be improved to an important degree. While a few decades ago their production – and especially molding and pouring practice – was based on empirical rules, technical progress did not come to a halt. Data were determined and rules were laid down founded on science. The modern German foundries have now so many improved means on hand that an excellent and uniform quality of the steel castings can be guaranteed.

Essential improvements to quality were brought about especially after World War II. Large castings can now be produced with greater accuracy. Alloyed steel castings corresponding to the safety regulations of various codes and conforming to design strength and quality can be made for the highest stresses.

However, the developments have by no means been concluded. Other problems are yet to be solved. In this connection one may point out that we in Germany are still at the beginning of the development of large castings of high-temperature austenitic steels.

*See Mr. Komers' article on p. 107.

Report From England

Program Control for Forging Press and Manipulator

*By TOM BISHOP**

BRITISH IRON & STEEL RESEARCH ASSOC. (B.I.S.R.A.) has been investigating the possibility that the motions of a forging press and a manipulator can be so coordinated and controlled by electronic devices that a hot billet can be reduced to a forged bar of simple cross section without any human intervention. This development has so far proved its success that a 200-ton forging press with hydraulic-driven manipulator is now in experimental operation at Sheffield. Its general arrangement is shown in the line drawing, and a photograph of the equipment in the halftone engraving.

The reason for this research project is based on the knowledge that the heating program for any large forging operation accounts for approximately half the total cost. Likewise that any delay at the forging hammer or press will magnify the heat lost by the ingot or billet by radiation and may even require an extra reheating. By speeding up the forging process and by coordinating the movements of forging press and manipulator, it should be possible to avoid much wastage of heat, increase the output of expensive equipment and consequently save money.

In most forging and pressing operations where the work weighs 100 lb. or more, the press is operated by lever or button pushed by the hammerman and works in conjunction with a manipulator or crane which handles the material to and from the press. The two machines are usually designed independently and controlled separately; the result is that optimum performance can never be obtained from either, even by a crew of highest skill. Manual control of the press usually results in more strokes than are really necessary. In addition, the crane, which is usually slow in operation, is frequently used for other jobs with the result that the press is never utilized to its full extent. For example, during a works' investigation it was found that a 2000-ton press was idle for 20% of its time for this one reason.

Work at B.I.S.R.A. has been with a 200-ton forging press and a fast-moving, rail-bound manipulator of unique design, the two being coordinated so the system can be translated into a regular production of forged bars.

The Press

By improving the hydraulic system of the press, the operating speed was increased to the required standard of 60 cogging strokes per min. Concurrently, a system of remote position control was developed which enabled the amount of squeeze to be predetermined to within plus or minus 0.06 in. Automatic control of the position of the crosshead was also provided between fixed limits.

The press is served directly by four double pumps, each with a high-pressure and a low-pressure side. The low-pressure side is automatically unloaded before maximum pressure is reached, in order to avoid overloading the electric driving motors.

The essential features of the new hydraulic controls are a two-position valve and a special prefill and exhaust valve. In the one position

*Consulting Editor, *Metal Progress;* John Miles & Partners (London) Ltd.

of the main valve, oil from all four high-pressure pumps enters below the ram so it moves up at a speed of 10 in. per sec. Meanwhile, the output of the low-pressure pumps passes back to the tank via the press cylinder and the prefill and exhaust valve. If the pumps are unloaded with the main valve in this position, the oil below the ram is trapped by a nonreturn valve, and the ram is supported in a stationary position. In the other position of the main valve, the pumps are connected to both sides of the ram, and the ram moves down.

The Manipulator

The design for the manipulator had to incorporate longitudinal motion, back and forth; accurate rotation through 90°, 45°, 22.5° and 9.5°; and adjustable height. It had to be accurate and fast enough to match the performance of the improved press.

A survey of available equipment showed that manipulators are generally of two types — either mounted on rails or completely mobile. Analysis showed that a machine which is restricted to one particular operation would be most efficient; consequently, a rail-mounted machine was chosen. A fixed external drive for longitudinal motion, forward and back (shown at the right of the side elevation in Fig. 1) was selected so the machine would be as light as possible, thus permitting maximum acceleration. The peel, jaws and motor were mounted on the carriage of the manipulator so that a comparison had to be made between the weight, size and power of hydraulic versus electric motors. In spite of the fact that the position-control for the press was electrical, it was decided that it would be best to use hydraulic machinery for all moving parts on the manipulator and to accept the disadvantage of having to use flexible high-pressure piping. These hoses are shown in Fig. 2; their upper ends are connected to horizontal piping supported by a horizontal I-beam overhead.

Traversing and rotation motors (hydraulic) for the manipulator are each controlled by solenoid-operated valves, which give quick response. To protect the motor and driving gears against a sudden pressure build-up when motion stops, decelerator valves open at any setting desired, thus bypassing the oil from the high-pressure to the low-pressure side of the motor. They are set at a pressure just above the normal maximum working pressure.

The oil supply to the gripping jaws is taken from the main circuit, the hand-operated valve, which needs attention only at the beginning and end of a complete cycle of operations, being mounted on the carriage.

The interlocked electrical controls for the

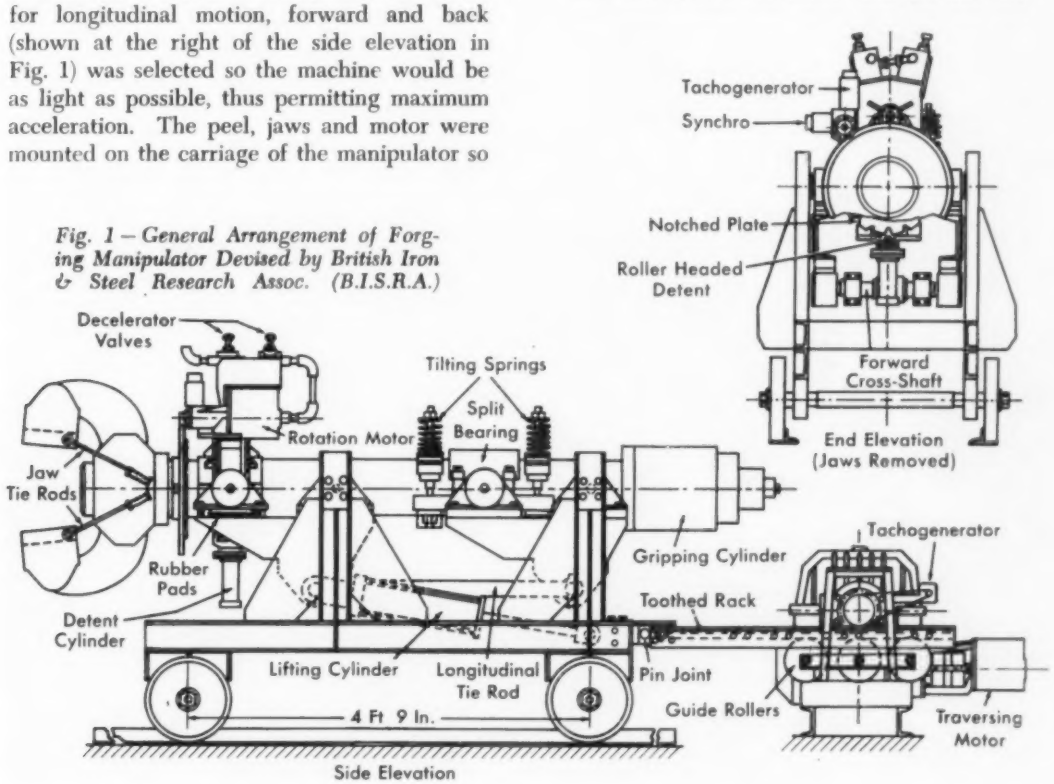


Fig. 1 — General Arrangement of Forging Manipulator Devised by British Iron & Steel Research Assoc. (B.I.S.R.A.)

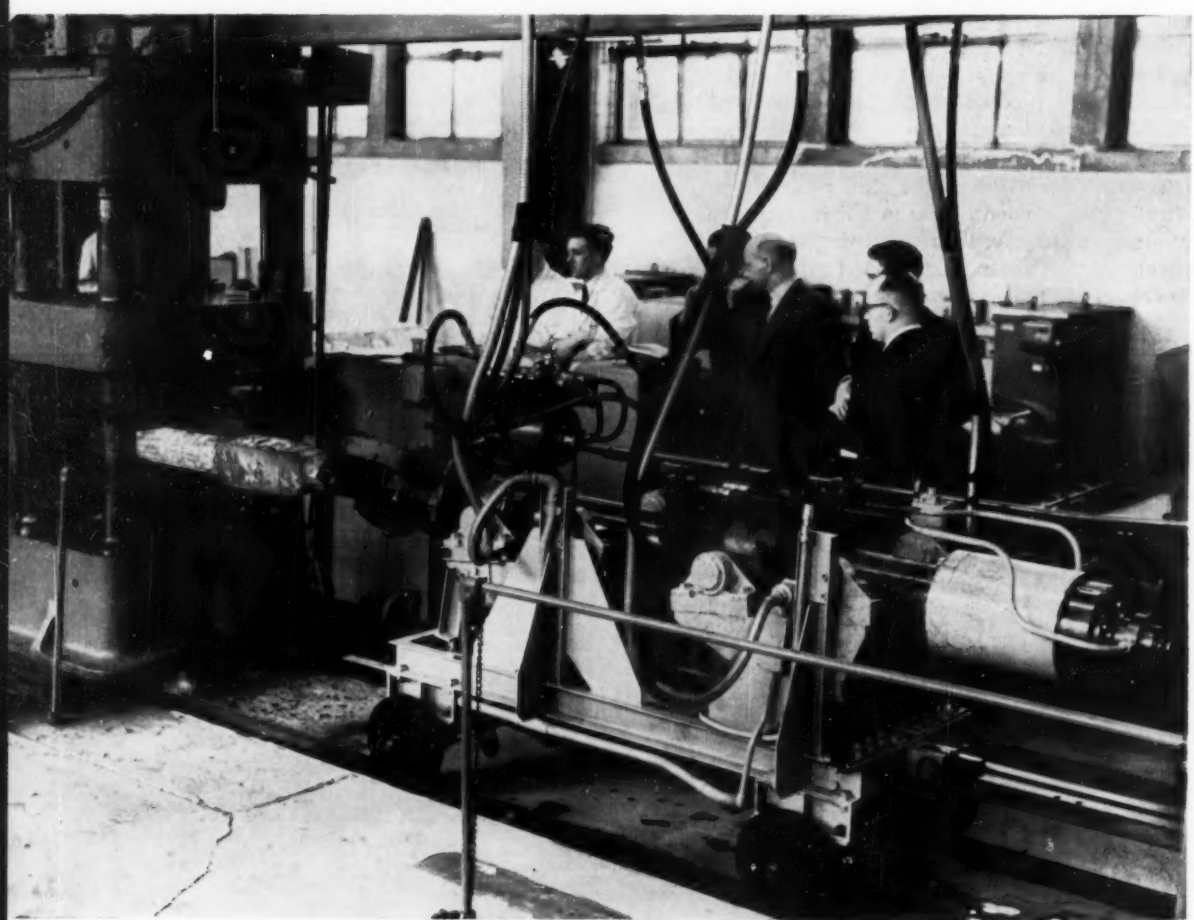
press and the three motions of the manipulator are similar in principle. The difference between voltages representing the desired and actual positions of a member is amplified and used to actuate the solenoid valves in such a manner that the resulting motion reduces the difference; motion stops when the voltage difference is less than a prescribed small value.

Motions of press and manipulator are coordinated by triggering the longitudinal travel and the rotation each time the press reverses at the bottom of a stroke. An automatic delay between successive short press strokes gives enough time for the manipulator to place the hot billet in a new position.

Complete program control is based on B.I.S.R.A.'s investigations of optimum metal movement or spread for each cogging or squeezing step in a particular forging operation — matters which previously have been left to the judgment of the expert press operator. Knowing what these successive movements should be, an automatic bank of electrical devices is not too difficult to construct. In fact, during recent trials of the coordinated equipment, a test forging was completed in 4.5 min. to better-than-average dimensional accuracy, wholly without human intervention.

Trials of this pilot unit are continuing. The surface finish and the accuracy of the work are most gratifying to the men on the project. Equipment manufacturers and steel forgers are already expressing keen interest in these trials at Sheffield.

Fig. 2 — An Experimental 200-Ton Forging Press Has Been Linked to a Fast-Moving, Rail-Bound Manipulator in Sheffield, England. The movements of these two machines have been coordinated to achieve an automatic forging process



Magnesium Castings in Europe

*By E. SAYLES**

Pressure die casting in water cooled molds gives sound parts of excellent surface at high production rates. Other manufacturing advantages make them competitive with aluminum where weight or inertia are important considerations. (T-general, 17-57; Mg-b, 5)

AT A JOINT MEETING held in England and Germany last summer by the American Magnesium Assoc. and the British Magnesium Industry Council, also attended by interested parties from all over Free Europe, optimistic statements were made about the situation the metal producers now find themselves in. World War II ended with large surplus stocks of magnesium ingot. Production in 1952 of about 125,000 tons of metal steadily declined to about 85,000 tons in 1955 while some of these wartime stocks were being released. Subsequent expansion to 105,000 tons (world-wide) in 1957 – the last year for which accurate statistics are available – and since then, warranted a feeling that the industry is a sound and growing one. Many interesting examples were cited of its use in mass-produced items for peaceful consumption, thus indicating that the future does not entirely depend on aircraft, missiles and rockets, which were uses prominent in remarks made at the meeting by our American cousins.

Price and Prejudice Retard Further Progress

Undoubtedly the greatest advantages of magnesium parts are their lightness for given strength, their extraordinary machinability and their good resistance to usual environments (except chlorides). While the fastest commercial aircraft may be able to pay $150 to save a pound of structural weight, the purchaser of an extension ladder has a different attitude. He will hesitate to pay $30 for one made of magnesium when he can get another made of aluminum for $20 even though it weighs twice as much, or $15 for a wooden one three times as heavy.

While magnesium ingot costs 40% more than aluminum ingot, many production executives and design engineers are realizing that first cost should not be the sole criterion of the choice of metal. Ease of casting and exceptional machinability (magnesium can be machined twice as fast as aluminum and ten times as fast as steel, generally without the need of any cutting fluid or coolant) economize in equipment and manpower, often resulting in a competitive price for a finished part.

Prejudice exists in many forms, chiefly against the imagined danger of fire. The use of magnesium powder for pyrotechnics and magnesium foil for flash bulbs for photography has unfortunately given a lasting but completely false impression of its combustibility. Although foil or finely divided particles burn readily, magnesium in the mass cannot be ignited below its melting point, 1200° F. Thus, nothing more than elementary fire precautions need be observed in foundries and machine shops, since fires are easily extinguished by dry sand, cast iron turnings or asbestos cloth.

For example, at Volkswagen's foundry at Wolfsberg, West Germany, with daily cast of about 100 tons, the fire hazard is shrugged off; good housekeeping has eliminated it. Magnesium turnings from the machine shops are briquetted for charging to the melting furnaces, and in this building the only fire precautions are a few small drums of iron filings and "No Smoking" signs. Naturally an accumulation of turnings is avoided and they are removed at frequent intervals and stored in metal bins.

Another deterring factor is the fear of corrosion. Normally, atmospheric corrosion itself is negligible and a magnesium surface can be left

*Consulting Engineer, John Miles & Partners Ltd., London, England. The author would like to thank the British Magnesium Industry Council for its assistance.

unprotected, but, as with all common metals, it will be affected under certain conditions. However, it must be emphasized that magnesium alloys are not attacked along intercrystalline surfaces and any corrosion which does occur is quite superficial.

Though not generally corroded by alkalis, magnesium alloys are susceptible to acids and especially chlorides. Best resistance of alloys is achieved if the iron and nickel contents are kept to very low limits (0.001 to 0.002%). In this respect, small additions of manganese have proved beneficial, but manganese is not necessary in alloys containing zirconium – they have very high chemical stability.

For castings likely to be exposed to corrosive conditions, spray coating or dipping gives adequate protection. For example, trouble with certain magnesium alloy parts stored for a long time in wooden boxes by reaction with tannic acid in the wood was avoided by painting with silicate of soda.

Protection is also conferred by "chrome pickling" or "chromating" – dipping in alkali chromates or dichromates – or coating with a thin film of selenium. Recently a cleansing process has been suggested by Magnesium Elektron Ltd. which removes cathodic impurities on the surface by a 10% solution of ammonium bifluoride and leaves behind a microscopically thin layer of magnesium fluoride which itself is a good resistor of corrosion and an excellent base for protective paints or baked-on resins.*

Conservatism is a further obstacle frequently encountered when promoting a new use or approaching a new customer. Difficult as it was in the past to persuade an industry accustomed to cast iron to accept aluminum, many believe that it has been even more difficult to effect the further change to an even lighter metal!

Applications of Magnesium Castings in Europe

That these prejudices are being surmounted has been shown by the satisfactory results achieved by progressive designers and industrialists. Magnesium alloys are being used in an ever-increasing range of applications, not only in situations best fitted to their particular properties but also invading the fields of established and equally suitable materials.

West Germany and Great Britain are without question the largest users of magnesium castings in Europe, and the rest of this article will be largely occupied with some notes from these two countries. From the limited information available, the principal applications in other Continental countries are generally in the aircraft industry, as will be seen from the following list:

France – Aero engines, aircraft wheels, missiles, tank idler sprockets, and sectional masts for jibs, derricks and other handling equipment.

Belgium – Parts for aero engines.

Holland – Parts for Fokker aircraft, molds for asbestos pipes, large tile pallets (pressure die cast).

Italy – Orpheus and Viper engines (Fiat and Piaggio), vehicle wheels (Alfa Romeo).

Sweden – Aero engines, aircraft parts, typewriter parts (pressure die cast).

Switzerland – Aero engines, aircraft parts.

West Germany – The outstanding example of magnesium castings in mass production is at the Volkswagen plant at Wolfsberg, West Germany. The daily output is 3200 cars, and each has a magnesium crankcase (20.5 lb.; Fig. 1), a transmission housing (13.5 lb.; Fig. 2), and other small castings with total weight of 38 lb. per car, thus requiring a daily cast in the foundry of about 90 tons of magnesium.† The history of this use is interesting.

When this little rear-engined car was being designed, during 1936 to 1938, it was realized that proper distribution of weight would be vital to road behavior and good handling. Consequently the crankcase and the transmission housing was made of magnesium alloy, chill cast in permanent molds. About 110 lb. (7% of the car's weight) was saved from what would have been necessary should cast iron have been used in these parts.

Permanent molds produce smooth castings, free from porosity. Die blocks are made of tungsten or molybdenum steels heat treated to C-30, and containing insets hardened to C-45. Life depends upon size and intricacy, being 20,000 to 30,000 for the difficult forms and 90,000 to 100,000 for the simpler ones. That magnesium has excellent bearing qualities is

*Paradoxically, many thousands of tons of magnesium-base anodes are used for the sacrificial protection of iron and steel in underground service.

†Production of magnesium ingot, currently, is said to be 27,500 tons per year, so the German industry is more than self-sufficient in this respect. However it is understood that Alcan (U.K.) Ltd. buys a very considerable amount of AZ 91 ingot from Canada. The Volkswagen's motor and driving gear housing is of GD Mg Al 9 DIN 1729 alloy: 7.8 to 8.8% Al, 0.1 to 0.8% Zn, 0.1 to 0.5% Mn, balance Mg with traces of Be.

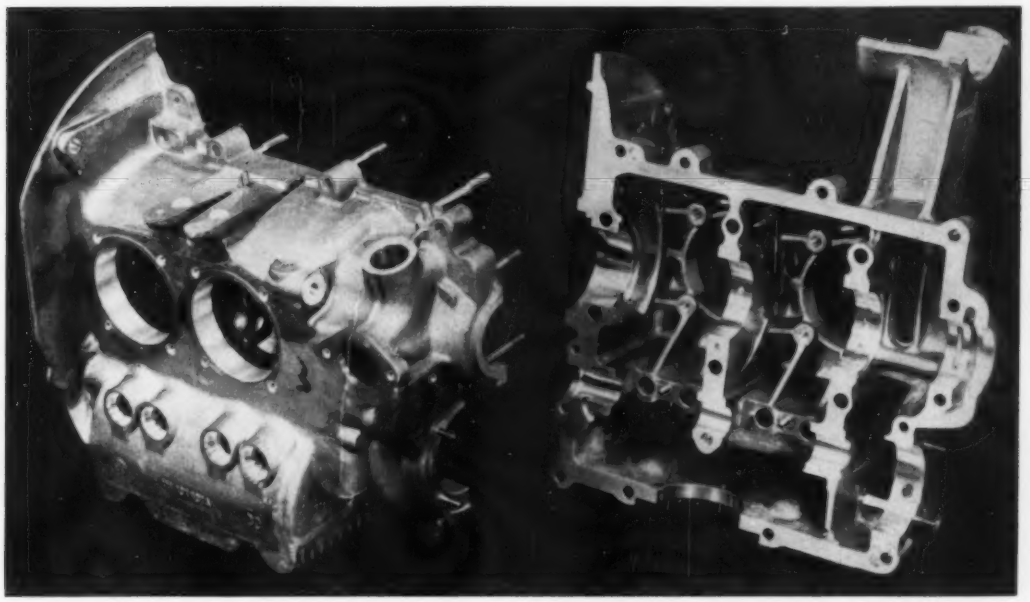


Fig. 1 – Crankcase, Left and Right Half, for Volkswagen. Finished weight 20.5 lb.

shown by the fact that the camshaft runs directly in the crankcase bore without bushings, and that camshaft gear wheels run as quietly "as if they were made of plastic". That it is readily machinable is illustrated by tool life which is more than four times that with gray iron, and cutting speeds which are twice as fast as for aluminum.

During the war, in 1943, the firm was required to convert all these parts into aluminum, even though all production was concentrated on Kubelwagen or "bucket-cars" for the military. Magnesium was reserved completely for aircraft. However, as soon as magnesium was again available, these main castings were reconverted. The present car also contains magnesium castings for some support brackets, steering gear covers and oil pump housings.

Beginning a few years ago the major items mentioned above have been made of pressure die castings – on balance a more economical method under the conditions existing at Wolfsberg. Metal is melted in electric induction furnaces. The dies are water cooled and the cast-

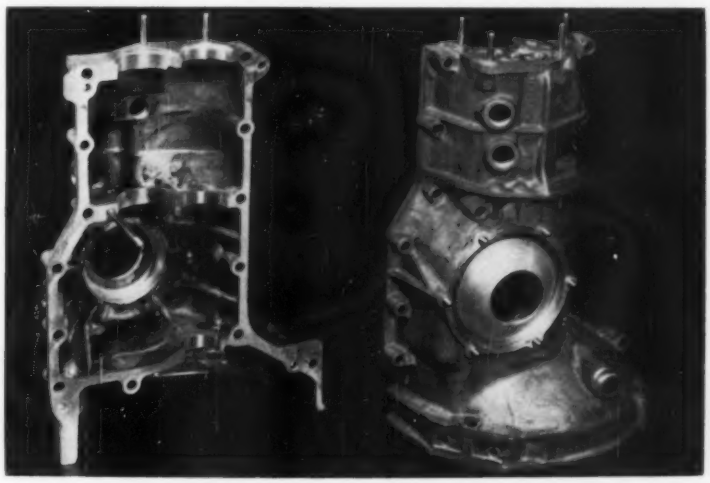


Fig. 2 – Transmission Housing, Left and Right Half, for Volkswagen. Finished weight 13.5 lb.

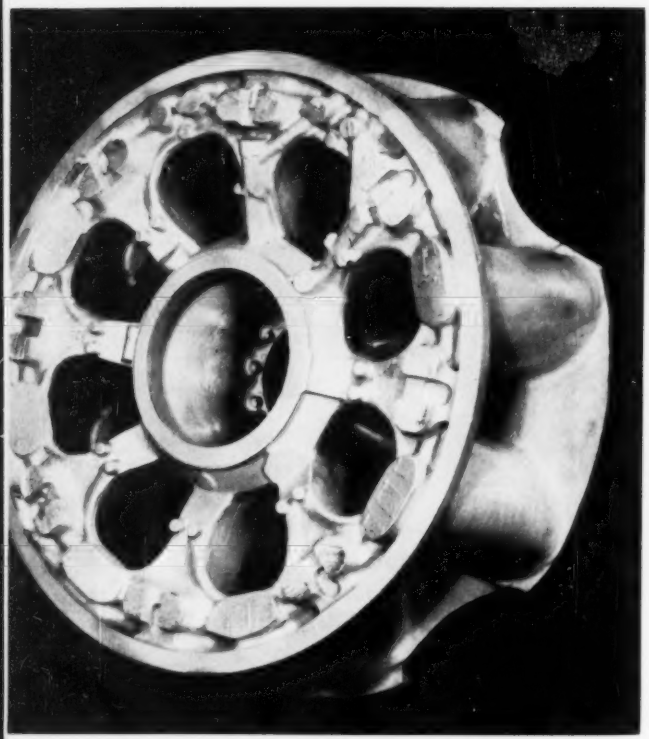


Fig. 3 — Air Intake Casting of Mg-Zr Alloy for Bristol "Proteus" Turbo-Prop Engine. Weight 183 lb. (Courtesy Sterling Metals, Ltd.)

ing solidifies in 18 to 20 sec. Sound castings of remarkably smooth surface are the result. One machine will produce about 30 castings per hour with a gross weight of about 15.5 lb. and a cleaned-up weight of about 11 lb. The transmission housing is not heat treated after casting, but the crankcase is annealed 2.25 hr. at about 480° F.

About the only disadvantage which Volkswagen engineers mention is the high thermal expansion of magnesium, but they point to the durability of their three million cars to prove that proper attention has been given to thermal deformation at bearings so the shafting will have proper play, or bushings (where used) do not loosen.

Other German motor cars use some permanent mold magnesium castings for wheels; also crankcases and engine gear boxes for "Mopeds" — motorized pedal cycles.

Many pressure die castings also go into typewriters and business machines, portable electric motors and fans, and household appliances.

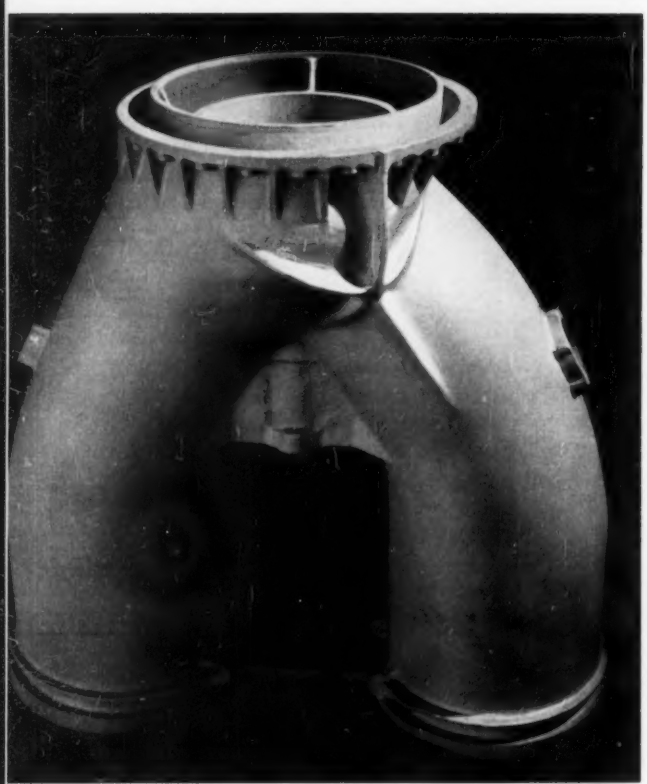
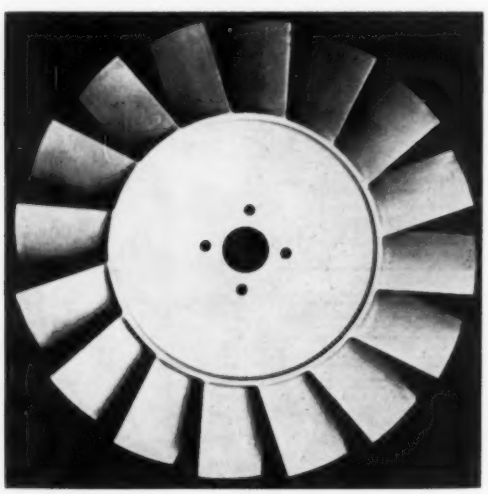
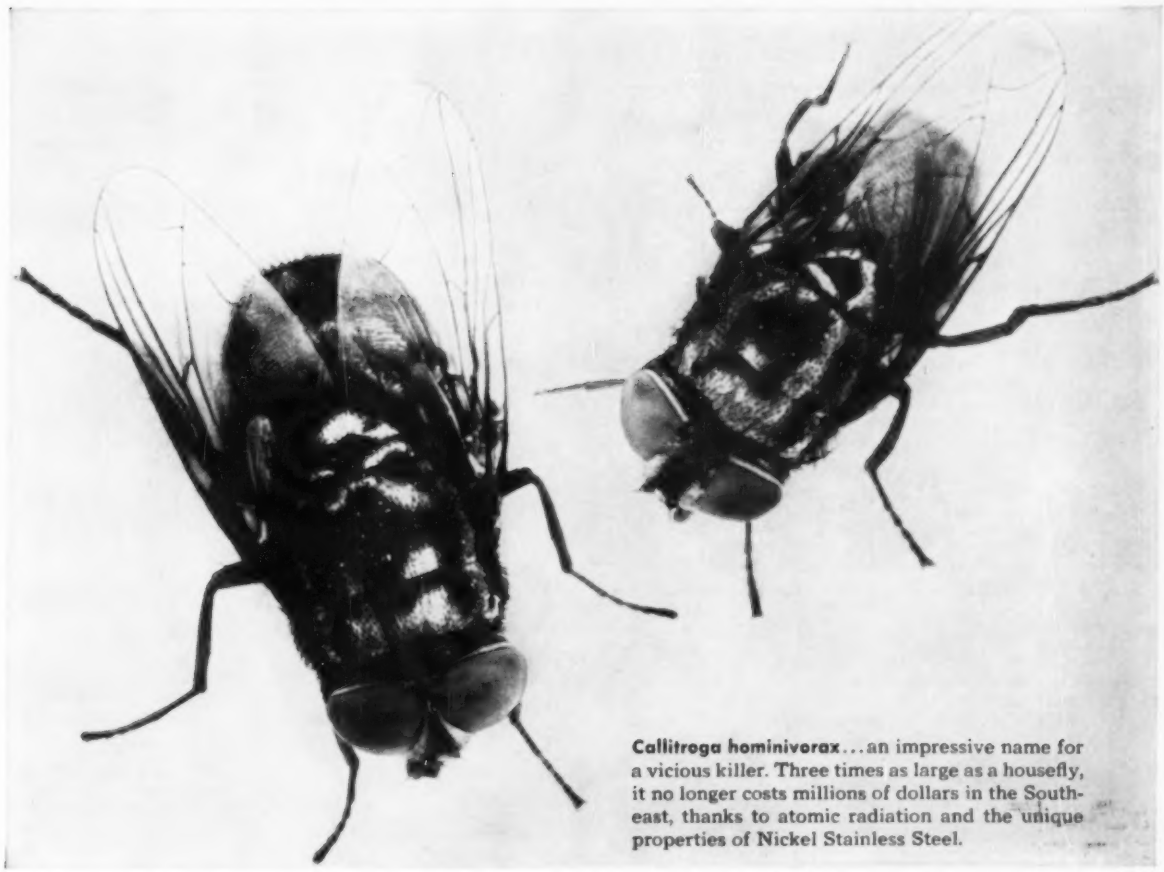


Fig. 4 — Main Duct Casting of MSR-B Alloy for Fairey "Rotodyne" Vertical Take-Off and Landing Aircraft. (Courtesy J. Stone & Co., Charlton, Ltd.)

Fig. 5 — Plaster Molded, Centrifugally Cast Fan, 13 In. Diameter. The blades taper from 0.10 to 0.03 in. Finished weight 20 oz.





Callitroga hominivorax...an impressive name for a vicious killer. Three times as large as a housefly, it no longer costs millions of dollars in the Southeast, thanks to atomic radiation and the unique properties of Nickel Stainless Steel.

Atoms clobber a $20-million-a-year pest

How Nickel Stainless Steel helped fight costly cattle menace

A few small flies can kill a full-grown steer in ten days.

They call this killer *Callitroga hominivorax,* or screwworm fly. It used to cost Southeast cattlemen 20 million dollars a year.

Thanks to a peaceful use of atomic energy, the U.S. Department of Agriculture reports that *Callitroga hominivorax* was completely eradicated within seventeen months. This achievement may mark a new precedent in modern methods of pest elimination. Over two billion laboratory-raised male flies were sterilized by atomic radiation and then released. Because the females then laid sterile eggs, the screwworm fly population was destroyed.

Sterilization was accomplished by exposing males to gamma radiation from Cobalt 60 within a lead-shielded cask of Nickel Stainless Steel.

Nickel Stainless Steel was chosen by the designers, Knapp Mills Inc., for several reasons. It gives strength and rigidity to the cask's interior for greater handling safety. It stands up to the nitric acid solution used for radioactive decontamination — a cleaning process that plays havoc with less corrosion-resisting metals. And its sanitary, attractive appearance adds sales appeal to any product.

Are you in the atomic energy field . . . or any field where you need a metal with a combination of superior properties? Consider the advantages of Nickel or one of its alloys when planning the construction of your equipment. Help with any metals problem is available from Inco. Just call or write us.

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The Irradiator, nemesis of screwworm flies, is fabricated of Nicrolum*—a Nickel Stainless Steel to which lead has been metallurgically bonded. Six of these machines brought the fly menace under control.

*T.M. of the designer-manufacturer, Knapp Mills, Inc., Long Island City, N. Y.

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British Magnesium Alloys

Alloy Designation	Condition	Tension (a)			Compression (a)		Endurance (a) (50,000,000 Reversals)		Hounsfield Impact, Ft-Lb.		Brinell Hardness (500 Kg.)
		0.1% Proof (b)	Ultimate	Elongation in 2 In.	0.1% Proof (b)	Ultimate	Unnotched (c)	Notched (d)	Unnotched (e)	Notched (f)	
Z 5 Z	Heat treated	19.0/23.5	33.5/40.0	5/12%	20.0/24.5	51.5/60.5	10.0/12.3	10.0/12.3	5.0/9.0	2.0/3.0	65/75
RZ 5	Heat treated	18.0/20.0	29.0/32.5	3/5%	16.7/21.3	48.0/53.0	12.3/13.5	10.0/11.2	3.0/4.0	0.5/1.5	65/75
TZ 6	Heat treated	20.0/24.5	37.0/42.5	5/15%	15.7/20.0	47.0/54.0	10.6/11.7	10.0/11.2	6.0/8.0	1.0/2.0	65/75
MSR-A	Heat treated	22.5	35.0	4%	22.5/27.0	45.0/56.0	14.5/16.2	9.0/10.0	—	—	70/90
MSR-B	Heat treated	24.5	35.0	2%	22.5/27.0	45.0/56.0	14.5/16.2	9.0/10.0	5.0/10.0	0.5/1.5	70/90
ZRE 1	As cast & annealed	11.0/13.5	20.0/24.5	3/6%	11.2/15.7	40.0/50.0	9.5/10.7	7.5/8.3	4.5/5.5	0.5/1.5	50/60
ZT 1	Heat treated	11.0/14.5	27.0/31.5	5/10%	11.2/13.5	45.0/47.0	9.5/10.7	8.0/10.0	5.0/6.0	1.0/2.0	50/60
MTZ	Heat treated	11.0	29.0	5%	—	—	4.0/4.5	—	—	—	50/60
A 8	As cast (g)	10.0/12.5	20.0/25.0	2/5%	10.0/12.5	40.0/50.0	11.0/12.5	8.4/9.5	2.0/3.5	1.0/1.5	50/60
(h)	Solution treated	10.0/12.5	29.0/38.0	6/15%	10.0/12.5	47.0/60.0	11.0/13.0	9.0/10.0	13.0/20.0	3.5/5.0	50/60
AZ 91	As cast (g)	10.0/13.5	18.0/23.5	1/3%	11.2/14.5	40.0/50.0	11.0/12.5	8.4/9.5	1.0/1.5	0.5/1.0	55/65
	Solution treated	10.0/13.5	29.0/36.0	4/8%	10.0/14.5	50.0/63.0	11.0/13.5	9.5/11.2	5.0/7.0	2.0/3.0	55/65
	Heat treated	14.5/19.0	29.0/37.0	1/4%	14.5/19.0	56.0/67.5	10.0/11.0	8.4/9.0	2.0/3.0	0.5/1.0	75/85
AZ 91 X	Die cast	11.0	27.0	4%	—	—	—	—	—	—	—
C	As cast (g)	9.0/12.5	18.0/24.5	2/5%	9.0/12.5	40.0/49.5	10.6/11.8	8.4/9.5	1.5/2.0	0.5/1.0	50/60
	Solution treated	9.0/12.5	27.0/36.0	4/10%	10.0/12.5	47.0/60.0	11.2/12.3	9.0/10.6	10.0/15.0	2.0/3.5	50/60
	Heat treated	11.2/17.0	27.0/36.0	1/3%	12.5/15.7	49.5/63.0	9.0/10.7	8.4/9.0	2.0/3.0	0.5/1.5	70/80

Alloy Designation	Typical Composition (i)	Approximate American Equivalent (j)	British Specifications			General Description
			Ministry of Aviation	Aircraft	General Engineering	
Z 5 Z	4.5Zn, 0.7Zr	ZK 51 A-T5	DTD 721 A		2970 MAG 4-P	General purpose high proof-stress structural alloy with useful properties up to about 300° F.
RZ 5	4.0Zn, 1.2RE, 0.7Zr	ZE 41 A-T5	DTD 748		2970 MAG 5-P	A variant of Z 5 Z, easily cast, weldable by argon-arc, pressure tight, with useful strength at elevated temperatures.
TZ 6	5.5Zn, 1.8Th, 0.7Zr	ZH 62 A-T5	DTD 5015			Stronger than Z 5 Z, as castable as R Z 5, weldable by argon-arc, pressure tight.
MSR-A	2.5Ag, 1.7RE*, 0.7Zr	QE 22 A-T6	DTD 5025			Heat treatable alloy with highest yield strength of any cast magnesium alloy up to 480° F. Pressure tight and weldable by argon-arc.
MSR-B	2.5Ag, 2.5RE*, 0.7Zr	QE 23 A-T6	DTD 5035			
ZRE 1	2.2Zn, 2.7RE, 0.6Zr	EZ 33 A-T5	DTD 708		2970 MAG 6-M	Creep resistant up to 480° F. Excellent castability. Pressure tight and weldable by argon-arc.
ZT 1	2.2Zn, 3.0Th, 0.7Zr	HZ 32 A-T5	DTD 5005			Creep resistant up to 660° F. Pressure tight and weldable by argon-arc.
MTZ	3.0Th, 0.7Zr	HK 31 A-T6				Creep resistant up to 660° F. for short-time applications. Pressure tight and weldable by argon-arc.
A 8	8.0Al, 0.5Zn, 0.3Mn	AZ 81 A-F		L 121	2970 MAG 1-M	General purpose alloy. Good founding properties. Good ductility, strength and shock resistance.
		AZ 81 A-T4		L 122	2970 MAG 1-W	
AZ 91	9.5Al, 0.5Zn, 0.3Mn	AZ 91 C-F		L 123	2970 MAG 3-M	General purpose alloy. Excellent founding properties. Pressure tight. Suitable for pressure die castings.
		AZ 91 C-T4		L 124	2970 MAG 3-W	
		AZ 91 C-T6		L 125	2970 MAG 3-WP	
AZ 91 X	9.4Al, 0.4Zn, 0.3Mn, 0.0015Be	AZ 91 A-F				General purpose, pressure die casting alloy.
C	7.5/9.5Al, 0.3/1.5Zn, <0.15Mn	AZ 92 A-F			2970 MAG 7-M	Cheap general purpose alloy with good average properties.
		AZ 92 A-T4			2970 MAG 7-W	
		AZ 92 A-T6			2970 MAG 7-WP	

Notes:

(a) Units of 1000 psi.
(b) Proof stress by offset method
(c) Using Wohler machine and round test pieces
(d) Semicircular notch, 0.047 in. radius, stress concentration factor about 2.0
(e) Round bar, 5/16 in. diameter, 1.75 in. long
(f) Same as e but with 45° notch at midlength, 0.01 in. radius at bottom, 0.083 in. deep
(g) Similar properties may be expected in annealed or "high-temperature stabilized" condition
(h) A variant, known as A 8 X, as die castings, has properties about the same as AZ 91 X
(i) RE means mischmetal, a mixture of rare earths
RE* is fractionated rare earth metals or "didymium" (85% neodymium and 15% praseodymium)
(j) See Data Sheet in *Metal Progress* for November 1959

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at Reduced Subscription Rates for American Society For Metals Members

The first, or "collector's" edition of a new American Society for Metals publication will be available this coming February, 1961. The new publication is a magazine well in keeping with the ASM tradition of editorial excellence. The new magazine is titled, "Metals Engineering Quarterly." ASM members may subscribe at reduced rates.

The content of the new quarterly will include technical papers presented at metals engineering programs developed and supervised by the ASM Metals Engineering Program Committee.

The new publication will serve as a sister publication to the well-known and respected ASM Transactions. But whereas the ASM Transactions is published to carry technical papers of a scientific nature, the Metals Engineering Quarterly will present technical papers of a considerably more practical nature.

For example, the February issue includes the following papers in its 112 pages:

HIGH-TEMPERATURE PROPERTIES OF RENÉ 41 AND ASTROLOY

PROPERTIES OF GRAY AND DUCTILE IRONS

FRACTURE TOUGHNESS OF STEEL FOR PRESSURE VESSELS

FAILURE OF STEAM-WATER HEAT EXCHANGERS

PROCEDURES FOR HIGH-TEMPERATURE FAILURES EVALUATION

APM ALLOYS

STRENGTHENING LOW-ALLOY STEELS BY DEFORMING AUSTENITE

REFINEMENT OF ALUMINUM-21% SILICON CASTING ALLOYS

Each of the above papers was presented at the recent 42nd National Metal Congress in Philadelphia. Future issues of the Metals Engineering Quarterly will contain other MEPC papers presented at the Philadelphia Congress, at regional metal congresses such as the 1961 Western Metal Congress, and from regional programs developed through MEPC throughout the year in various parts of the country.

The Metals Engineering Quarterly has no counterpart in ASM publications and has been created to offer ASM members the opportunity to obtain practical, useful information on a wide variety of subjects at the least cost possible.

The Metals Engineering Quarterly will be issued in February, May, August and November of each year. The magazine will be 8½ x 11 in size. Binders will be available for the four Quarterly issues. ASM members may subscribe at a rate of $6.00 per year. (Non-members, $10.00 per year.)

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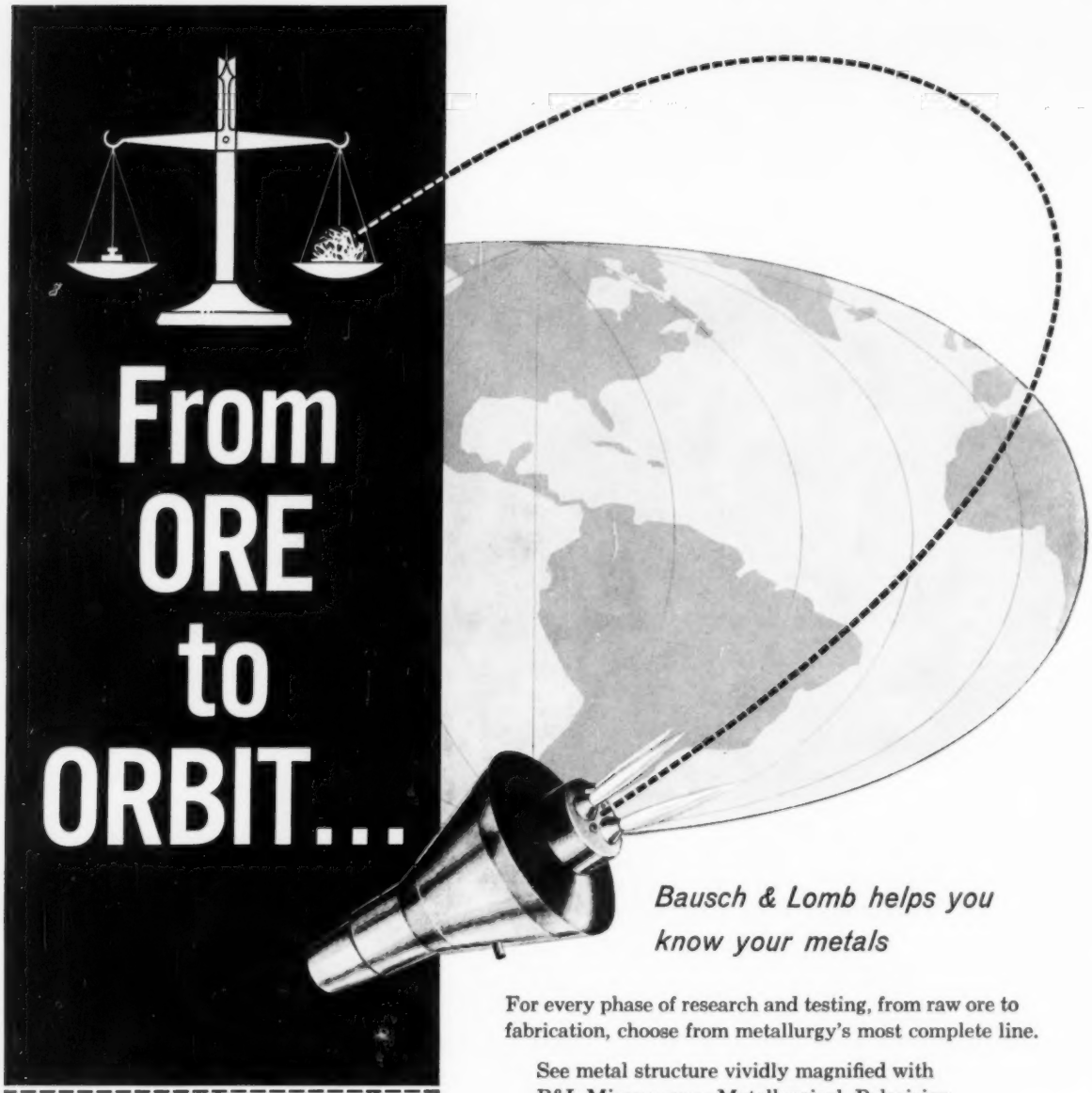

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Circle 442 on Page 49-B

Magnesium sand castings get into cylinders and beds of printing presses, and into hand tools of a wide variety.

Great Britain

In comparison with the above, the production of magnesium castings in England is rather small. Totals for 1958 and 1959 are comparable and average as follows:

Sand and gravity castings (permanent mold)	
Aircraft and engines	1100 tons
Automobiles and heavy vehicles	400
Printing, agricultural and miscellaneous	275
Missiles and military	110
Textile	45
Pressure die castings	
Appliances, business equipment, photographic, electronic	55
Total	1985 tons

In view of its outstanding strength-to-weight ratio and its good ratio of fatigue endurance to ultimate stress, it is not surprising to find that the bulk of Britain's output of magnesium castings is used in the aircraft and missile industry. While there has been a steady increase in use for automobiles and heavy vehicles, this happy situation is not apparent in the other branches of industry.

For many years aircraft landing wheels have been made in magnesium and during the war more than a million were cast with practically no failures.

The Rolls-Royce "Dart" engine (as used in the Vickers Viscount) includes 82 castings in ZRE 1 alloy. The same magnesium-zirconium alloy is used for the air intake casting shown in Fig. 3. This item is used for the Bristol "Proteus" turbo-prop engine, four of which power the "Britannia" aircraft. A sand casting weighing 183 lb., this is a typical example of the complicated castings manufactured in this series of magnesium-zirconium alloys.

A reduction gear casing weighing 164 lb. for the Napier "Eland" assembly is cast in magnesium-zirconium alloy RZ 5.

Magnesium alloy castings containing rare earth (RE) metals and especially zirconium have been successfully introduced since the war and are now available in several specifications. They are rather costly; they have superior properties of great interest to the aircraft builders (for example, see Fig. 4), but they have not yet been adopted to any extent in peacetime industry. The MSR alloys, as shown in the Data Sheet, p. 100-B, contain silver, rare earth metals and zirconium, and are given a two-stage heat treatment.* Two are in production, MSR-A and MSR-B, the former having a slightly lower proof stress but greater ductility and toughness than the latter. Both retain their properties at higher temperatures; up to about 500° F. they are said to be stronger than any other magnesium casting alloy.

Some automotive uses are worthy of mention. One of the first sand castings to be made in quantity is a casing for the worm wheel at the rear axle of a trolley bus. The flywheel cowl is exposed to scuffing from passengers, being at the end of the aisle, but such castings have served splendidly. The cooling fan shown in Fig. 5 cuts production costs and reduces wear on the fan belt.

While unconventional materials are seldom found on agricultural equipment, the largest order ever placed in Britain for magnesium castings was probably the sand-cast transmission case, weighing 52 lb., and the permanent mold cast gear box top (8.25 lb.) used on the Ferguson tractor. During the life of this model, 600,000 sets of castings were produced in commercial alloy.

Weight is especially important in equipment whose motion must be reversed rapidly, as occurs in much textile and printing machinery. Since the textile industry is one of Britain's oldest, this is indeed one in which tradition dies hard, but the lightness and consequent low rotary inertia of magnesium castings have found their uses in items previously made in other metals or wood.

For example, in a modern high-speed machine, yarn is wound from bobbins onto a beam or roller at 3000 ft. per min. If the yarn breaks, the backing drum must stop in one revolution, and to minimize the inertia forces these drums are made in commercial magnesium alloy, weighing between 230 and 525 lb. according to the size.

The dynamically-balanced high-speed warp

*Heat treatment for MSR-A is 4 hr. at 975° F., quench in hot water at 150° F., age 16 hr. at 400° F. For MSR-B it is the same except the first heating is for 8 hr.

In their paper at the joint meeting Messrs. Eade and Beck stated: "Little trouble has so far been experienced with distortion of castings in heat treatment or with dimensional instability. It is to be expected that castings with a low inherent stiffness might well require special jigging in heat treatment. Close attention is, however, necessary to the time lag between removing from the furnace and quenching, if maximum properties are to be obtained."

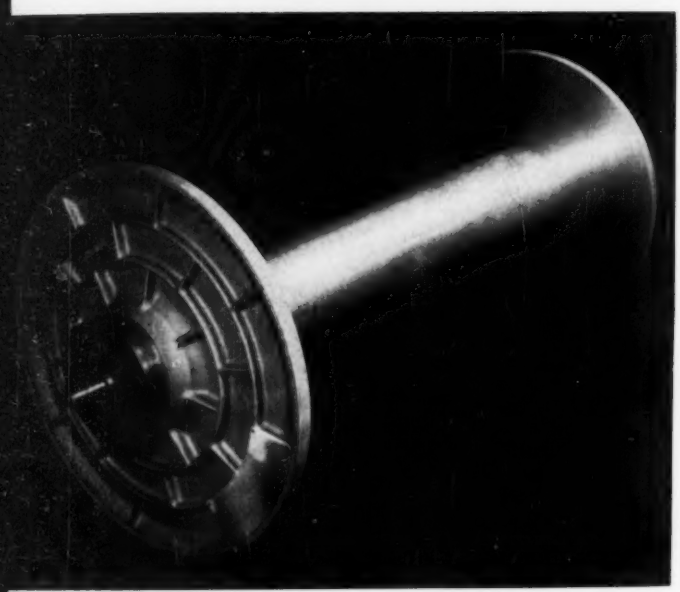


Fig. 6 – Drum for Textile Machine, 30-In. Flange, 10-In. Barrel, 54 In. Long, Weight 194 Lb.

beam shown in Fig. 6 is sand-cast in commercial alloy. Brake drums are bolted to the ends. Though these beams have to be light for manhandling, their flanges must withstand end-loading – and certain synthetic yarns can impose a side thrust of 18 tons on a 30-in. flange. The barrel itself must withstand the hoop stress of the yarn and the whole must have sufficient rigidity to retain its manufactured dimensions under these conditions. Most beams are sand cast, because sizes are not standardized.

Reciprocating bed plates for printing presses are a good example of the use of Mg-Zr rather than cast iron to reduce inertia effects – in fact they increase running speed as much as 50%. Previous efforts to use steel were defeated because when the bed was lightened, it lost its necessary rigidity.

An even more striking example is the use of magnesium pulleys for the duplex Beché drop hammer. Two 40-in. diameter pulleys are used, each weighing about half a ton, and around them run steel belts supporting 60-ton tups. When forging, these pulleys oscillate through 180° three times every second. Formerly they were of cast iron but the belts overheated and required frequent attention. The lightness of magnesium reduced the inertia stress set up by rapid reversals and cured the belt trouble.

Casting practice calls for no particular comment except that factors governing speed of direct chill casting operations must be rigidly controlled to give top-quality castings of good surface finish.

Since magnesium oxidizes rapidly, certain precautions are necessary in melting and casting these alloys. At all times the liquid metal must be continuously protected by an inert atmosphere such as SO_2 or argon. Sulphur and boric acid are mixed into the molding sand. Cores made by the CO_2 process are used.

Sufficient flux must eliminate all contaminants during the refining stage, but it must be completely removed prior to pouring. An excess of flux must be avoided, not only because of the risk of flux inclusions, but also to prevent unnecessary attack on the steel crucible. Workmen in the melting shop must see to it that all pot walls, pouring lips, launders and distribution equipment are kept clean.

Since any slag in the pouring ladle sinks to the bottom, the metal surface should be dusted with sulphur. At the end of the pour the residual sludge in the ladle can be centrifuged to separate the magnesium. One firm recovers 70 lb. of metal per 1000 lb. of slag.

At Britain's largest jobbing foundry the metal is melted in oil-fired furnaces, in deep drawn, mild steel ladles of up to 600-lb. capacity. It is cast at 1435° F. The permanent molds have renewable inserts on impact faces; the molds are tilted for easy flow of the liquid metal.

Since thermal capacity of the metal is low, melting and cooling are rapid, and reliable methods for controlling temperature are necessary. The metal does not absorb gas readily, so nonporous castings can readily be made. Sand castings are sound, pressure tight, free from internal defects and can have excellent surface finish.

In spite of the higher cost of ingot metal, pressure die castings in magnesium are usually cheaper than in aluminum because the dies normally last at least twice as long and the short "dwell" required for solidification gives a much faster production rate. Since the cost of the dies is relatively high, this can have an appreciable effect on the final cost of the product; where weight of the article must be kept to a minimum to attract the buyer, magnesium's advantages are further emphasized.

The general feeling in the industry, therefore, is that there will be a steady development in the use of magnesium products rather than a spectacular rise in the near future.

Centenary of the German Metallurgical Society

*By KURT THOMAS**

Although it has a comparatively small membership, Verein Deutscher Eisenhüttenleute is extraordinarily active in German educational and standardization activities, and through its publications – 30% of which circulate abroad – has had unusually large influence on the international scene. (A12g, A2; Fe, ST)

Facade of National Offices in Düsseldorf, Miraculously Undamaged by Bombs in World War II

ON NOV. 3, 1960, THE VEREIN DEUTSCHER EISENHUTTENLEUTE celebrated its hundredth birthday. It is therefore appropriate to leaf back through the pages of history and recall the reasons for its organization and to chart, if only briefly, its progress through the century.

If we try to transport ourselves back to 1860, we must recall that the English iron industry then was the leading producer. For example, it made twice as much pig iron as the United States and Germany combined, and was far ahead of all the countries of the world in steel production.

The German iron industry could better be described as the iron industry of the German customs union of the time; this comprised a loose combination of numerous small states and countries in a German alliance, more geographical than political, and it found itself at the time in a very oppressed condition. A preceding boom had reached its peak in 1857, and brought numerous new plants into being and expanded many of the existing ironworks. By 1860 the demand had not only declined but strong competition was added, especially from England and Belgium. Many firms were in difficulties.

Of the 38 million persons living within the boundaries of Germany, almost half then lived on the land. Only a fourth part were engaged in industry, including mining. The Ruhr territory was still in the beginning of its development. The puddling process was in its flower,

*Manager ,Verein Deutscher Eisenhüttenleute, Düsseldorf, West Germany.

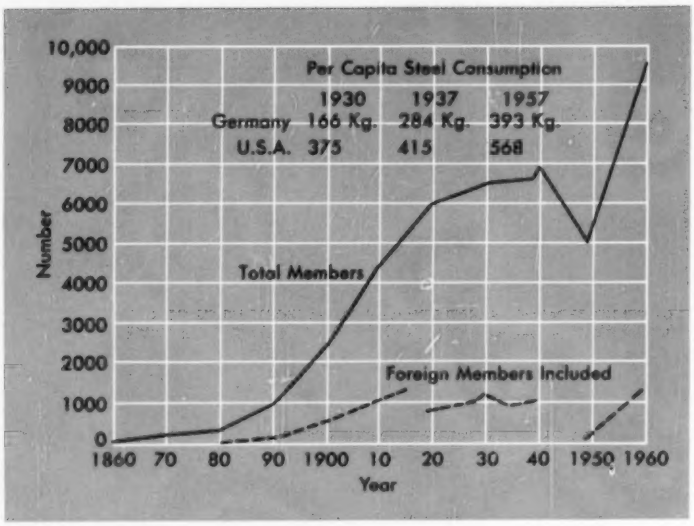


Fig. 1 – Membership Growth

and was able to supply metal for railroads, bridges and hardware. The small smelting units and the heavy labor of skilled workmen did not lend themselves to high production. Thus the 1860 output of the German customs union amounted to 545,000 tons of pig iron and only 426,000 tons of wrought iron. A great many very small blast furnaces were still in operation, from whose open fronts the puddler or the molder dipped out his requirement of liquid pig iron with a hand ladle, as if from a cooking kettle! The blast furnaces had heights of little more than 50 ft., and rarely a capacity of more than 3000 cu.ft. It was the period of transition from a charcoal fuel to coke, from the refining hearth to the puddling process, and the replacement of water power by steam drive. The age of bessemer steel was still to come.

In economics, individualism was paramount. Guilds and civil and corporate combinations had collapsed; the state had returned to free trade. Equalization and general harmony were expected to result. In this situation a few far-seeing men came together and formed a Technical Society for the Metallurgy of Iron, whose task it should be to correct the bad business

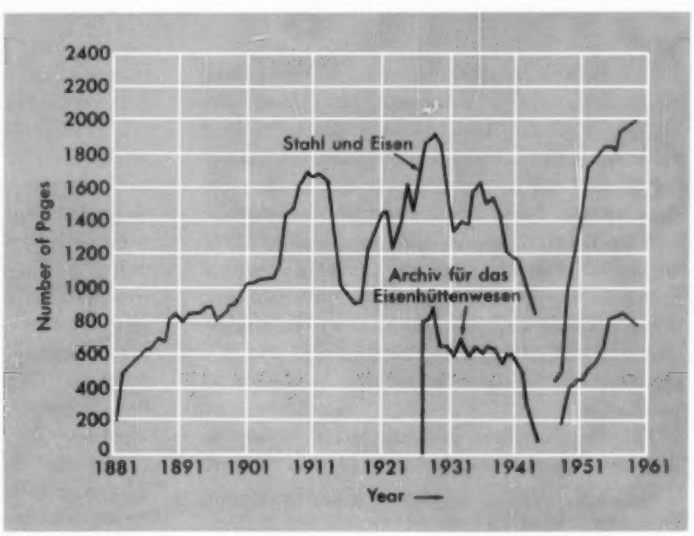


Fig. 2 – Reading Pages Published Annually by the Two Journals of VDEh

situation by perfecting the operations, by improving the product and by cautious plant management. The intention was to promote metallurgical technology by cooperative effort, by lectures, by the exchange of information and by joint investigations.

We must regard this decision as a conscious renunciation of the almost universal secrecy then practiced; it opened a path whose value has since been recognized by many organizations throughout the civilized world. To evaluate this step we must remember that the old methods of making iron were about to be eliminated by new converters and openhearths, and that great economic advantages beckoned to the enterprise which made a decisive advance through its own effort, or gained a lead over others.

The bylaws of the newly founded Society contained all the provisions which still serve to advance metallurgy today. The only notable lack was a periodical publication – but such an expenditure must have appeared beyond the means of that first very small group of members. Therefore they became a branch of the Society of German Engineers (Verein Deutscher Ingenieure) – then four years old.

As the years went by, the technical and economic conditions in the iron and steel industry were stabilized. Indeed a revolution occurred with the manufacture of low-carbon steel by the new methods. The desire for complete autonomy grew stronger, and in November of 1880 the "Technical Society" became completely independent and adopted the name

Verein Deutscher Eisenhüttenleute

which may be freely translated as "Society of German Iron Masters" and is abbreviated as VDEh. Within a year the first number of its periodical *Stahl und Eisen* appeared (July 1, 1881), an event commemorated in *Metal Progress* in its issue of January 1957.

While the VDEh has not nearly so large a membership as some American engineering societies, its growth through the century has been steady (except for the catastrophic years of World War II). This is shown graphically in Fig. 1. Membership is by no means confined to the Teutonic countries – indeed its total of 1250 foreign members (165 in the United States) represents a proportion probably unmatched by any other similar organization.

All those who wish to cultivate the technical and scientific aspects of the iron and steel industry are united in the Verein Deutscher Eisenhüttenleute. It includes as regular members persons who have completed their education in the higher technical institutes (Hochschulen), persons with long engineering experience, and administrators in industry and trade, insofar as they are associated with technology and especially with metallurgy. Students can become junior members after a certain period of study and practice.

The president of the Society since 1950 has been Hermann Schenck, professor and director of the Institute for Metallurgy of the Rheinisch-Westfälischen Technischen Hochschule in Aachen. Since 1954, the manager, whose duties also include the task of editing the entire literary output, has been Kurt Thomas.

Professional Committees

The actual professional work of VDEh is done by specific professional committees serving all important branches of metallurgical practice, from ore and coke through the blast furnace to the steel plant and the rolling mill, to further processing into shapes and on to testing the product. Their work is stimulated by contact with the plants and laboratories, and by observing the developments abroad and in neighboring regions. Close cooperation is maintained with the Max-Planck Institute for Iron Research, with research staffs in educational institutions (especially those which have professors of metallurgy), and also with the allied professional societies and organizations at home and abroad.

Each professional committee is guided by a Chairman, assisted by the management of the Society. Subcommittees are appointed as needed to handle special questions. There are 20 such professional committees at the moment, as well as several smaller working groups. Since the individual plants of the German iron industry, as sustaining members of the Society, bear the cost of the professional committees, the members of the latter are limited to those who are active in a German metallurgical plant, or as a teacher on an engineering faculty. Of course, guests may be introduced at any time.

The amount contributed by the individual plants is computed as a uniform assessment per ton of pig iron, ingot steel, or mill product.

The first such standing professional committee was established very early – in 1880 – and dealt with metallurgical machinery. Since then a great many committees have been appointed for specific purposes, later to be dissolved when

Fig. 3 – Meeting Room of the Professional Committees at the Home Office

their work was finished. They have been most efficient in handling the rapidly developing scientific and technical knowledge and the constantly increasing number of specific questions besieging the metallurgist – matters which could not be handled in crowded general assemblies, or by lectures to large groups. It is here especially that Otto Petersen, business manager of the Society from 1917 to 1946, deserves recognition for organizing the committee work and promoting cooperation.

A somewhat special group with its own laboratories is the fuel economy and production control office, which supplements the work of the professional committees. Its principal activity is in the field of heat and power economy. It was founded in 1919 to deal with the then existing fuel shortage and in 1923 it extended its field to production control. At present it also studies questions concerning metallurgical water control, technical statistics and industrial physiology.

Local organizations, such as the "chapters" of the American Society for Metals, were anticipated in the bylaws drawn up in 1880. The first such branch was formed in 1893 and others were organized in various parts of Germany where the iron industry was concentrated. They worked closely with the parent Society in Düsseldorf. World War II, which divided Germany into East and West, put an end to their activity until 1956, when a branch society in Saarbrücken was organized.

Promotion of Research and Teaching

A century ago the embryonic technical society endeavored to promote scientific work, for in 1862 it considered plans for a metallurgical experiment station. Almost 10 years later the same question was taken up again, since in the meantime the United States Board to test iron and steel had been established by A. L. Holley. Its activities made a great impression on the German experts. Nevertheless, it was more than 40 years before the idea of founding an iron research institute to serve the common need was transformed into reality. Success came in 1917 – to some extent as a result of the united technical and scientific work performed within the bounds of the Verein Deutscher Eisenhüttenleute – with the foundation of an Institute for Iron Research for free scientific research in iron and steel. Scientifically it has become a branch of the Kaiser-Wilhelm-Gesellschaft (now the Max-Planck-Gesellschaft) for the promotion of science. In 1935 extensive new buildings were turned over to this Institute in Düsseldorf. *(Continued on p. 140)*

Status of Welding Processes in Europe

*By MAXIMILIAN KOMERS**

Notable progress has been made in the production of strong, tough steels of good weldability, and in devising various schemes for delivering powdered flux and protective atmospheres simultaneously to the arc. Electroslag welding is still under experimental study. (K1)

IF WE CONSIDER TECHNICAL DEVELOPMENTS of welding in the industrial countries of the free world during the last 15 to 20 years, we find that it is continually (and to a greater degree) supplanting other joining methods such as riveting, bolting and press fitting.

The chief reliance of mass production is on electric arc welding and electric resistance welding; the earlier oxy-acetylene welding is disappearing, being replaced by the modern shielded arc welding. Automatic processes are making great advances. Manual welding is also being distinctly improved by the use of lime-coated electrodes.

European countries have taken over many of the new methods from America and have perfected some of them further. But they have also followed original paths. I will attempt to recount the present status of the electric fusion welding processes used in Europe. Naturally there can be no claim to completeness.

Weld-Safe Steels

Steel fabricators, especially, have required special welding techniques and materials to meet their requirements. Thus, even before World War II, bridges were welded completely in Belgium and Germany. Shipbuilders also availed themselves of this method of joining. Naturally there were setbacks. After being in use a short time, cracks were found in and near the joints in some bridges; some bridges even collapsed. This led to the discovery that not all kinds of metal – considered according to the steelmaking methods – could withstand the bi-axial or tri-axial stresses, especially with unannealed welds, or that they could relieve these stresses by small plastic movements. The same conclusions were reached in the United States after a study of the brittle ships made during the second World War.

In the meantime, metallurgists succeeded in making what we call "weld-safe steels". Messrs. Harris and Williams, in an article in *Metal Progress* for April 1959, indicate that – given a design and fabricating practice which introduces no sharp notches in the structure – brittle fracture at and below 0° F. can be avoided in plate made of killed steel of the following composition: 0.24% max. C, 0.04% max. P, 0.05% max. S, 0.60 to 0.90% Mn, 0.15 to 0.30% Si. Its tensile specifications are 32,000 psi. min. yield strength, 58,000 to 71,000 psi. tensile strength, and 22% min. elongation in 2 in. This development has advanced even further in Germany, so that even stronger steels – up to about 65,000 psi. yield strength – can be safely welded. Weld-safe carbon steels are also manufactured, with moderate amounts of manganese and very small additions, for example, of titanium with controlled nitrogen content.

Weld-safe steels are equally important for

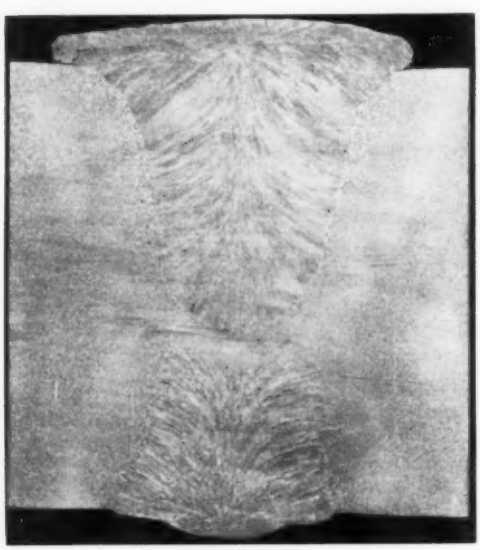
*Chief Engineer, Phoenix-Rheinrohr, A.G., Düsseldorf, West Germany. Chairman, Committee XII of the International Institute of Welding on "Special Arc Welding Processes".

the fabricator of pressure vessels. In Europe today we have steels for boiler drums which are excellent for welding and have a tensile yield strength of 50,000 psi. when tested at 660° F. (350° C.). Thus the builder can build with thinner walls. In addition to the well-known chromium and chromium-molybdenum steels, there are steels with additions of copper and nickel which show an especially favorable stability in those quickly cooled regions alongside welds. Good weldable steels with good physical qualities facilitate the whole construction process, especially shaping and fitting.

Welding Under Powder

The most important welding process used today in Europe, especially for mass production, is what we know as "welding under powder", taken over from the "submerged-arc" process of the Americans. In time the various European countries have begun to make the equipment and the powder within their own borders, but only slight differences have appeared in its use in the two continents. For example in England and Germany, plates more than 2 in. thick are united by a single V-joint, and plates double that thickness can be welded as a double V-joint with a deposit from each side.

Fig. 1 — Macrograph of Joint, As-Welded, in 6-In. Plate Made by Double-Head Welding Under Powder. A single pass fills about one-third of the seam; the assembly is then turned over and the remainder filled by a single pass of two welding heads, one trailing the other



In the so-called double-head welding of thick plates (U.S. patent No. 2,620,423) the first pass is done as usual from one side, filling the joint 1 to 2 in. up to that surface, then the other side is filled in one pass but with two electrodes, one following the other at a distance great enough so that the puddle from the leader is largely solidified before the second one finally fills the seam. This eliminates the large columnar crystals which otherwise would form, and which often cause cracks in the joints. Figure 1 shows the crystallization pattern in such a weld in plate 6 in. thick.

This technique has been widely used in circumferential joints of heavy cylinders and pressure vessels. For a specific example, the 3-in. final weld in a 5-in. plate is made with two electrodes; the leading one is 0.40 in. diameter and carries 3300 amp. at 45 v.; the other, trailing 7 in. behind, is 0.31 in. diameter and carries 1800 amp. at 55 v. With such heavy currents, the powder must be low in manganese or manganese oxide (or free from it) but the advantage is that the welding is fast and the joint is free from slag inclusions and porosity.

Under-powder welding has a definite weakness, namely, that the impact values are comparatively low. This does not have any ready metallurgical explanation, since the joint analyzes very low in oxygen and nitrogen, so we should suppose the impact values to be very good, especially at low temperatures. On the other hand, the toughness of weld metal deposited from basic (lime-covered) electrodes is known to be surprisingly high. For submerged-arc welding it is therefore evident that the powder must be more basic than the usual material and, as mentioned above, very low in MnO. Tougher metal has been reported from the use of a powder in which the silica content is largely replaced by alumina, but such powders can only be used with currents up to about 1000 amp. However, it may be more than the silicon content of the powder which affects the results, and tests now indicate that more progress can be expected in the near future in the field of under-powder welding.

Worthy of mention in this connection is a process which resembles under-powder welding. It has an open arc, but a sheath of magnetic powder encircles the wire in its length between the current supply and the end. The magnetic powder thus replaces the covering on a jacketed electrode. This old idea has been recently taken up again in connection with the

shielded-arc welding process, in that the powder sheath supplements the protective gas – argon or CO_2 – and protects the molten puddle.

Electroslag Welding

The Russian process of electroslag welding, devised by B. E. Paton at the Paton Institute of Electric Welding in Kiev, and said to be used in that country commercially since 1951, has aroused great interest among experimenters in Free Europe. (See *Metal Progress*, February 1960, p. 118 and 123.) A sketch of the setup is given in Fig. 2. It differs from the submerged-arc method discussed above since the electrode is melted as well as the adjoining edges of the plate by heat derived from a puddle of molten slag. In other words, the operation starts off as under-powder welding until a mixture of powdered oxide is melted by an arc passing from the electrode to the adjoining metal (or from electrode to electrode). But when the arc has melted and superheated a sufficient amount of this powder, the descending wire electrode is melted by the heat of the liquid slag bath, and this heat is maintained by resistance to the flow of further current without an arc. Joints can only be done in a vertical seam (or at a slight slope) from the bottom upward. At the working zone the joint is sealed off by water-cooled copper plates which move upward as welding procedes.

According to reports from Soviet Russia, this method is economically usable for butt joints in plate over 1 in. thick, and slabs up to 40 in. have been welded in this way. The equipment is ordinarily installed for plates 4 in. or thicker, and uses three wires about ⅛ in. diameter. In order to obtain an even weld for thick cross sections, the wires move sidewise slowly like a pendulum. Using alternating current and a three-phase transformer, one wire can be hooked to each of the three phases. For especially thick sizes (up to about 40 in.) equipment with 18 electrodes has been built, six electrodes on each phase.

The amount of wire melted off, that is, the electrode feed, indicates the welding speed and is affected by the amperage. These two factors must therefore be correctly synchronized. The distance between the abutting edges also plays a part; it varies between 1 and 1½ in. All conditions should be so adjusted that the amount of molten metal is one half to one third the volume of the molten slag. A shallow slag bath results in greater penetration of molten metal into the edges of the joint and a deeper slag bath in less penetration. The height of the slag bath is therefore constantly probed with a tungsten contact, and fresh powder added automatically as necessary. Figure 3 is a photograph of an apparatus made by the German General Electric Co. (AEG).

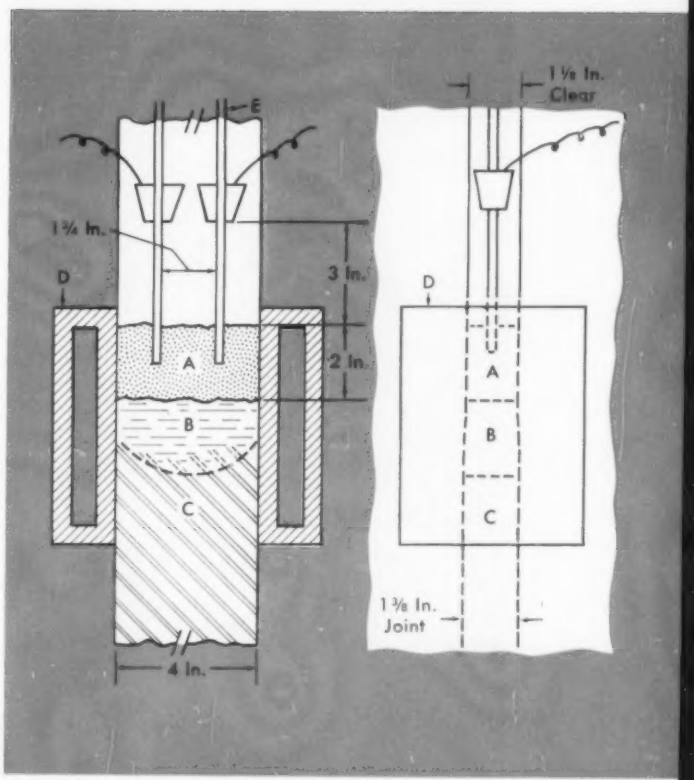


Fig. 2 – Sketch of Electroslag Welding Process (Adapted from Welding Research Supplement, *June 1957, p. 200-s). A is molten slag; B is molten weld puddle; C is solid weld metal; D is water-cooled copper plate; E is ⅛-in. electrode (700 amp., 45 v.)*

Formulation of the slag requires a delicate balance of electrical resistivity, melting point, viscosity low enough so it won't stick and high enough so it won't leak out alongside the copper dams, and acid and basic oxides so adjusted that the weld metal will not pick up silicon or manganese. About 20% of CaF_2 is added to react with the 20 to 35% SiO_2 and produce enough SiF_4 to prevent porosity – especially when welding rimming steel containing considerable iron oxide.

One apparent difficulty is the pronounced structure of vertical dendrites in the weld; this

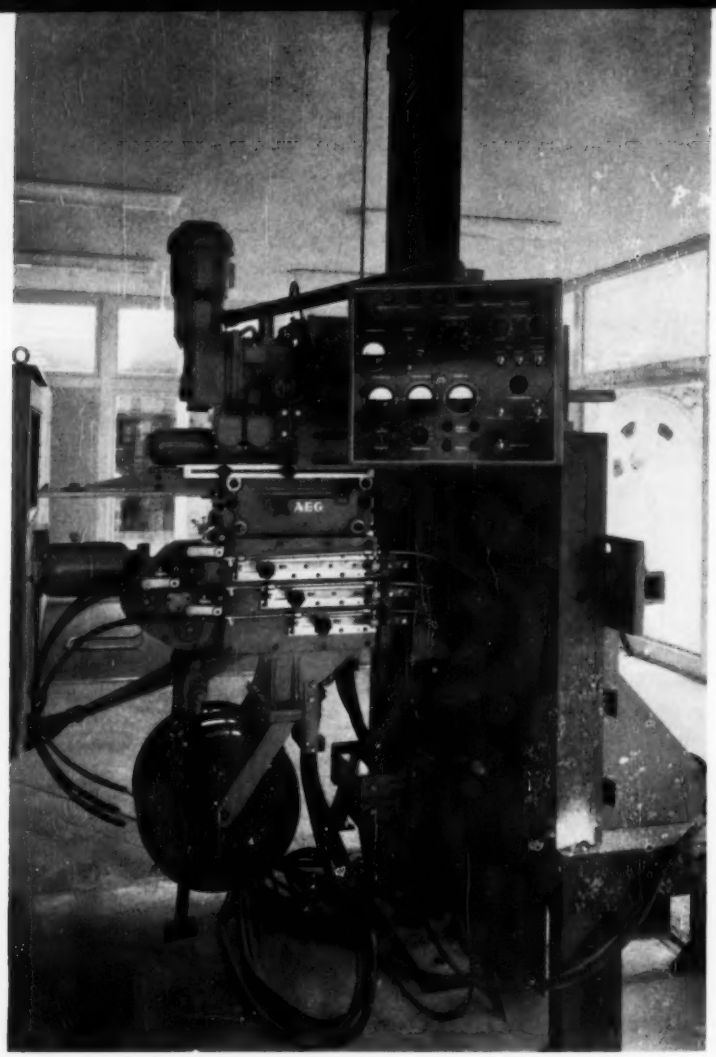


Fig. 3 – Equipment for Three-Phase Electroslag Welding, Made by German General Electric Co. (AEG)

promotes hot cracking. This trouble is associated with a shallow puddle of molten weld metal; a deeper puddle will result in dendrites growing at an angle of 45° to the axis and less danger of hot cracks. These conditions are exaggerated because the process is much more deliberate than multi-pass arc welding; the width of the heat-affected zone alongside is 0.60 in. for electroslag, eight times as much as for multi-pass arc welding.

Fusarc and Other Processes

Another automatic welding process devised in Europe is called "Fusarc" in which the coating is held fast to the electrode by spirals of fine wire (Fig. 4). These so-called net-mantle electrodes can be used on any automatic machine. They are made with either acid or basic coverings, although the basic is preferred. Most of the current is carried by the outermost

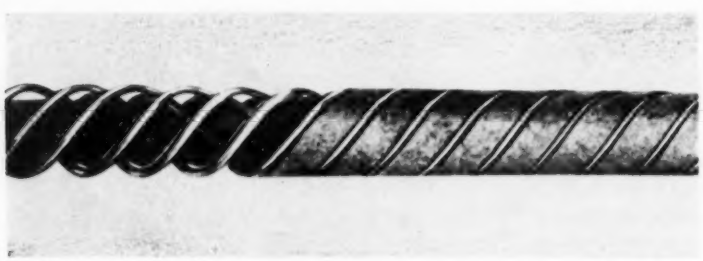


Fig. 4 – Sketch Showing Construction of Electrode for Fusarc Process. Coating is held tightly by spirals of fine wire

thin spiral; an electrode with 5-mm. (0.20-in.) core-wire can pass a maximum of 600 amp., producing joints comparable with submerged-arc multiple-deposit welds.

The advantage of the Fusarc is that difficulties involved in the delivery and recovery of powder are eliminated. It has found wide acceptance in Europe in recent years in shipbuilding, steel construction and tank erection.

Another European method uses a bare wire electrode, with the same advantages. As shown in Fig. 5, the wire is actually covered by two mantle chains placed around the electrode, one from each side, just below the incoming current contact. This cover is a series of short (about 1 in.) half-shell segments, connected end to end by two thin wires, and wound up on spools thus permitting a continuous feed. Since the electric current, as in submerged-arc welding processes, is led in at a short distance above the arc, welding can be done with higher amperage – that is, at a greater rate of deposition. It is especially useful for making overlays.

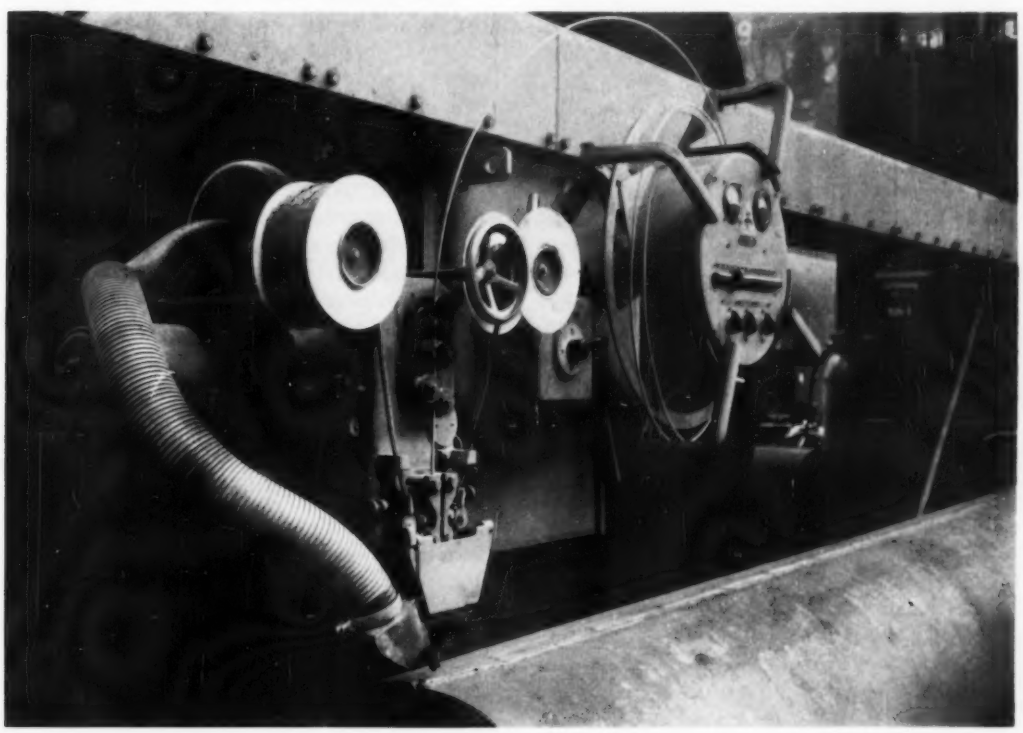
Fig. 5 – Automatic Machine for Mantle-Chain Welding. A bare electrode is covered by half-round segments (pressings of coating materials) just below current intake

A third method of introducing metal and flux simultaneously to the seam being welded is sketched in Fig. 6. A thin strip of steel is drawn through roll formers and a final die, finally emerging with the crumpled cross section somewhat as shown, and filled with proper slag-forming materials in powder form. Such electrodes in coils are adaptable to continuous welding on automatic machinery. The welding head shown simultaneously projects a stream of protective gas – usually CO_2.

Still another method of making short straight seams – especially in sheet or thin plate – is the "Elin" whose essentials are sketched in Fig. 7. A wrapped electrode of proper length, up to 6 or 7 ft., is laid in the V-notch seam and clamped down under a grooved copper block. Current is led in from one end of the electrode, an arc is struck between the other end and the grounded work, and melting and welding progresses gradually toward the other end. Alternating current seems to be preferable.

Shielded Arc

Various kinds of shielded-arc welding are widely practiced in Europe today, most of them originating in America. Since we have no



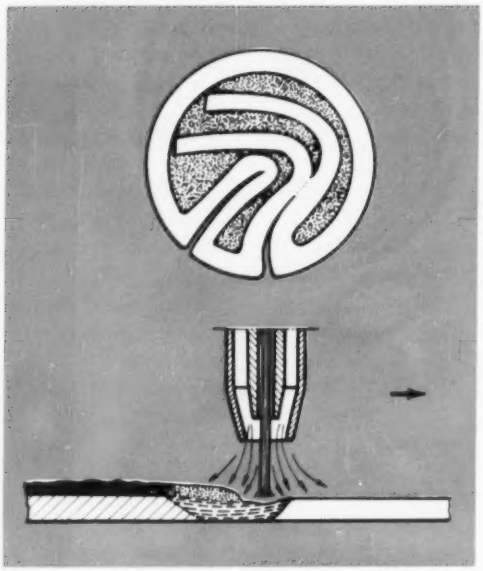


Fig. 6 – Enlarged Cross Section of Chambered Electrode Filled With Powdered Flux, and Method of Operating With CO_2 Shield

natural sources of helium, we rely principally on argon and CO_2.

At first argon welding was used, either with nonconsumable tungsten electrodes or with consumable electrodes, for alloy steels and especially for stainless alloys and light metals. Welding of ordinary carbon steel, with the addition of 3 to 5% oxygen to the argon, has been supplanted by CO_2 welding. Occasionally a mixture of argon and CO_2 is also used to insure pore-free seams in unalloyed steels. The simultaneous use of slag-making powder and protective gas has made remarkable progress. Protective gas (CO_2) also considerably improved operations of the mantle chain, described above, especially when the mantle had a high content of rutile, thus producing a stable arc and a very smooth seam. The slag from such coatings is easily removable. One precaution is necessary: Minerals containing any water of crystallization must be rigidly excluded from the coating. When this is done, the CO_2 protective gas gives all the good results of low-hydrogen electrodes.

The above principles with minor variations have been widely used for welding of high-pressure boilers, in shipyards and for joints in structural steel. It is also a success when heavy built-up layers are necessary.

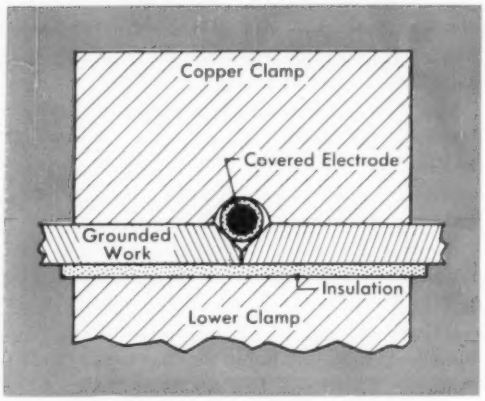


Fig. 7 – Sketch of "Elin" Process for Welding Straight, Short Seams in Thin Plate or Sheet

Manual Welding

In spite of the rapid advance in automatic equipment, manual welding has not lost its significance. Coated electrodes have also been improved. The basic or lime-covered electrodes have notably bettered the characteristics of the joint as soon as the welder becomes accustomed to this kind of electrode which requires different handling. But this difficulty can be quickly overcome, and there are now electrodes of this type which the welder can use to good advantage in even the most difficult of situations.

A further advance may be seen in the making of "deep fusion electrodes". With some of them, abutting plates ⅜ in. thick can be welded flush in one pass. Of the numerous other special electrodes which have been put on the market by European manufacturers, only those may be mentioned which promote a high production rate resulting from a high content of iron powder in the coating.

Conclusion

Within the limits of the present report it is impossible to describe – even mention – all the developments in the field of automatic machines and hand welding. Many methods have acquired only a local or temporary significance. Furthermore, the improvement of welding techniques in Europe (as in America) has not yet reached its limit, by any means. Researches currently in progress encourage us to hope for much more progress in this field of engineering production.

Decorative Plating Abroad

*By A. C. BENNING**

Although some electroplaters still rely on buffed copper-nickel-chromium systems for decorative parts, many have adopted plating practices such as duplex nickel and crack-free chromium which were developed in this country. (L17, T21; *Cr, Ni*)

THE ECONOMIC REBIRTH of Europe which has followed World War II has resulted in a great increase in the production of automobiles, appliances and other consumer goods. With it has come a great demand for metal finishing processes to provide the necessary decorative appeal and corrosion protection for these products. Unfortunately, most of Europe was understandably slow in developing techniques for applying decorative finishes and therefore came to rely on the processes developed in the United States.

Plating in England

To meet the imposed demands of more severe corrosive conditions on automobiles in the export markets most platers in England employ electroplating processes developed in the United States and to some extent in Germany. As in this country, the automotive industry has accepted duplex nickel (see *Metal Progress*, March 1960, p. 112 and July 1960, p. 69) as the most promising answer to the corrosion problem on bumpers and other exterior components. Duplex nickel consists of a double layer of electrodeposited nickel, the first layer being a sulphur-free, semibright coating and the second layer being a compatible bright nickel deposit. This is, of course, followed by an outer coating of chromium.

In contrast with countries on the Continent, most electroplaters in England apply the nickel deposit directly on steel rather than over a buffed copper surface. One major automobile subsidiary of a U.S. firm still uses buffed copper as an undercoat.

In addition to duplex nickel, heavier crack-free coatings of chromium or double layers of chromium deposited from different plating processes have also received much attention. Evaluation of different plating systems has resulted in further interest in accelerated corrosion tests. Although the British Standards Institute (B.S.I.) has specified the sulphur dioxide test, there is considerable interest in the merits of the Corrodkote test (used by Chrysler and Ford) and the CASS test (used by General Motors), developed as a result of work by the American Electroplaters' Society.

To emphasize to the public the benefits of properly electroplated decorative finishes applied under rigid specifications, Mond Nickel Co. Ltd. has embarked on a highly publicized scheme which is intended to restore confidence of consumers in electroplated products. In collaboration with the British Non-Ferrous Metals Research Assoc. and the British Standards Institute, Mond developed a "Quality Label Scheme" to try to eliminate substandard plating. Labels to be applied to plated articles (Fig. 1) are issued by Mond, at cost, to manufacturers. These indicate that the electrodeposit is guaranteed to meet one of three specifications (Table I) and that the nickel and chromium are properly applied and sufficiently thick for the type of service intended. The color of the label indicates suitability for severe, moderate, or mild

*Harshaw Chemical Co., Cleveland. Mr. Benning spent nine weeks in Europe early in 1960 attending technical conferences in Sweden and England and surveying the European plating industry.

Table I – British Standard 1224:1959; Thicknesses of Electrodeposited Coatings*

Service Conditions†	Basis Metal	Designation	Nickel Thickness (Minimum)
Severe	Steel	Ni 12 S	0.0012 in.
Severe	Copper or brass	Ni 6 C	0.0006
Severe	Zinc alloy	Ni 10 Z	0.0010‡
Moderate	Steel	Ni 8 S	0.0008
Moderate	Copper or brass	Ni 3 C	0.0003
Moderate	Zinc alloy	Ni 6 Z	0.0006‡
Mild	Steel	Ni 4 S	0.0004
Mild	Zinc alloy	Ni 3 Z	0.0003‡

*Chromium thickness 0.00001 in.

†Red, blue or green labels (see Fig. 1) are attached to plated parts to indicate that the coating is suitable for severe, moderate or mild service, respectively.

‡Copper deposit (0.0003 in.) may be omitted if other provisions in the specifications are met.

service. The scheme is being promoted and publicized by mail, television commercials and advertisements in magazines and newspapers.

As in this country, aluminum and stainless steel have made some inroads into decorative trim for automobiles. Aluminum has, however, been restricted mostly to simple stampings such as grillwork; stainless steel is used mainly for body and window moldings.

German Platers Active

Germany, more than England, has proprietary decorative plating processes of its own. Because of the extensive use of buffed copper in Germany, there is less need for bright copper processes. Also, because leveling in bright nickel is less significant over buffed copper, it is not emphasized in the bright nickel processes of German origin as much as in the United States. Here, leveling is of great importance in covering polishing marks left in the steel basis metal.

But the greater rate of development in the United States has led to an increasing reliance on American methods. The German manufacturer has recognized the value of research and automation and has accepted the fruits of foreign ingenuity to advance his country to the lead in the race for export markets. As a result, the German supplier of processes, materials and equipment is dominating the European Economic Community, made up of Germany, France, Italy, Belgium, Holland and Luxemburg, by rapidly expanding with subsidiary companies and agents in the rest of Europe. American metal finishing suppliers are beginning to invest in Germany either directly or indirectly although at a slower rate than in postwar England. Competition with German firms is keen.

Buffed Copper Still Used

The automobile producers in Germany have tended to overemphasize the appearance of the plated parts on cars, including the small models for the mass market, even at the expense of corrosion resistance. As a result and because of lower cost of labor, most German specifications still call for a buffed copper layer applied on the basis metal before depositing bright nickel and chromium coatings. There is considerable activity, however, in the evaluation of duplex nickel systems. Two of the top manufacturers of automotive zinc die-cast parts are already using this system.

Since a large portion of the parts supplied to the automotive industry must pass the Kesternich corrosion test (sulphur dioxide), they are being plated with heavy crack-free coatings of chromium to give satisfactory results. However, failure of these parts in service, because

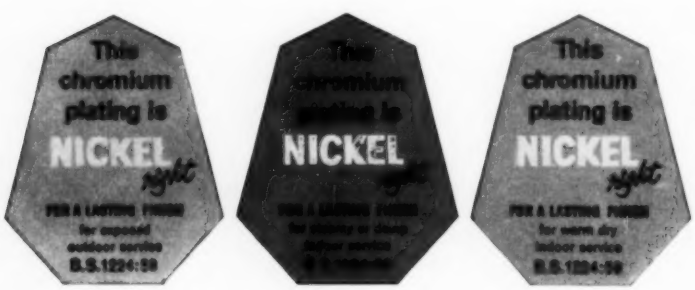


Fig. 1 – Users of Plated Products Get Assurance of Quality of Electroplate in Program Launched by Mond Nickel Co., Inc. Tickets, labels (left) and leaflets which are attached to parts indicate by their color whether thickness of the coatings is satisfactory for severe, moderate or mild service conditions

of inadequate nickel (especially since corrosive salts are being used more for ice removal from streets), has led to considerable interest in duplex nickel. In addition, re-evaluation of accelerated tests appears to be leading to the acceptance of the Corrodkote and CASS tests as replacements for the sulphur dioxide and standard salt spray tests.

There are definite signs that the application of nickel directly on steel may be accepted, especially in view of improvements in automatic polishing equipment for obtaining an acceptable finish on steel before applying leveling nickel deposits and chromium. A large manufacturer of "prestige" cars is already using this system on hub caps.

room to be fastened to body of the car.

An apparent anomaly to this insistence on a decorative finish in which appearance is taken as the important measure of quality is the acceptance of anodized aluminum on one make of car, the product of an American subsidiary. The satin finish, which contrasts with the high finish on plated parts, is comparable to that of anodized aluminum trim on some U.S. cars.

The electroplating industry in France has lagged behind that of other countries and therefore we find extensive reliance on U.S. processes for decorative finishes of nickel and chromium. Considerable education of the electroplater is needed to increase his awareness of the problems of corrosion, particularly in foreign mar-

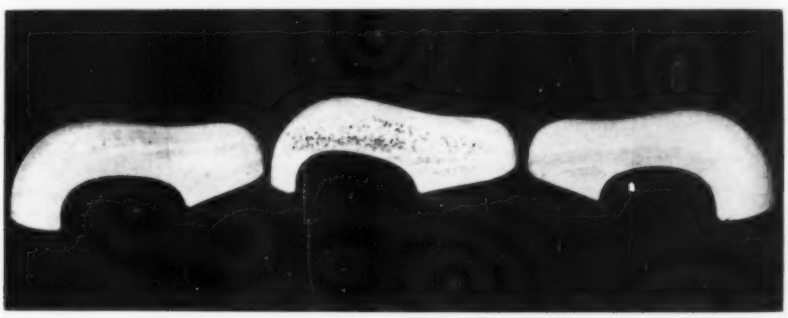


Fig. 2 – Accelerated Corrosion Tests on Bumper Guards from Germany Indicate Advantage of Duplex Nickel. Left: 0.0016 in. duplex nickel and ordinary chromium; center: 0.0008 in. buffed copper, 0.0008 in. bright nickel, crack-free chromium; right: 0.0008 in. buffed copper, 0.0008 in. duplex nickel, ordinary chromium. Two cycles in Corrodkote test (paste has not been removed) reveal that duplex nickel gives better performance than same thickness of bright nickel

Parts Made From Brass

In contrast with the practices in other countries, some German automobile manufacturers still fabricate many decorative parts from brass.

This reduces the need for a heavy electrodeposited coating of nickel and chromium to obtain corrosion resistance. In some instances a heavy chromium layer is deposited directly on the brass and is then buffed to obtain a high luster. As an example of the emphasis on quality of some top-line cars, all brass trim such as grilles and moldings are fitted to the car by hand to assure perfect matching. After being hand filed and shaped to insure perfect fit, the parts are removed, numbered and sent to the plating room for buffing and plating. They are then inspected and returned to the assembly

kets, and to get him to apply suitable deposits of sufficient thickness to meet the standards of other countries.

Suppliers of U.S. processes can play a vital part in bringing about an acceptance of the techniques and processes necessary for sound specification coatings. With the development of the European Economic Community, German suppliers of processes and equipment "migrated" into the French electroplating field. Eventually there may be a German domination of the metal finishing industry because of superior equipment, techniques and processes relating to polishing, cleaning and plating.

Count on Stainless Trim

Because of the poor reputation of plated decorative coatings from the standpoint of corro-

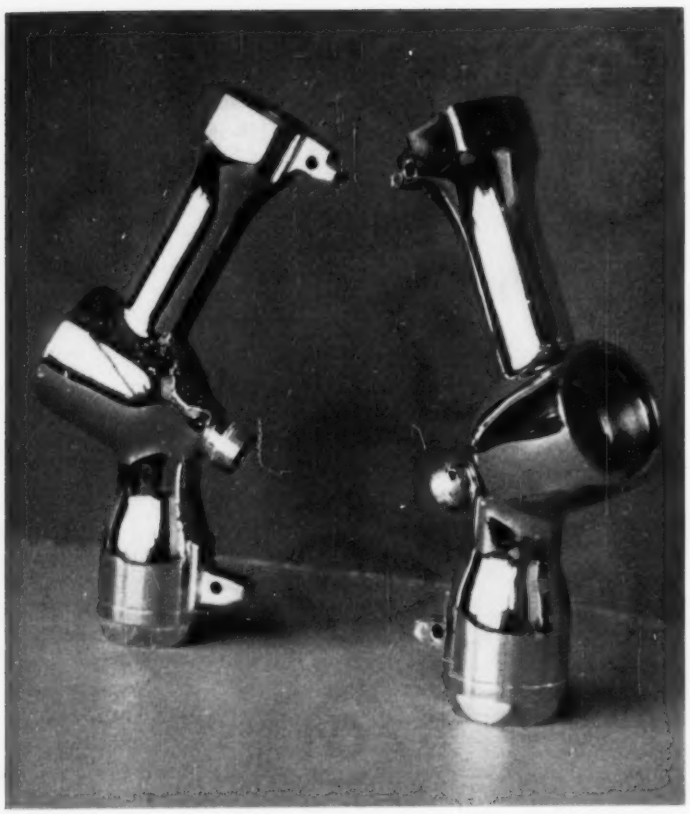


Fig. 3 – Corrosion Resistance of Zinc Die Castings Is Improved by Plating With Duplex Nickel. Both parts are plated with 0.0004 in. cyanide copper, 0.0008 in. bright nickel, 0.00001 in. ordinary chromium. Part at left: bright nickel; right: duplex nickel

sion, some auto makers in France avoid plated trim almost entirely. The Peugeot, for instance, makes extensive use of stainless steel for external trim including bumpers. Trim on the Panhard is aluminum, but here the absence of rust does not make up for the poor appearance and low strength of the particular alloy used, especially on bumpers. With improved plating systems becoming available to provide adequate corrosion resistance, we can expect these firms to re-evaluate their use of these metals.

Duplex nickel, although it is being used on bicycle wheel rims, is not yet accepted by French automotive makers as it is in the United States and England. Buffing of copper and nickel is still extensive, but there is a decided trend toward leveling bright nickel processes.

Plating in Other Countries

The electroplating industry in Italy is of interest to Americans mainly because of the increase in exports of Fiat and Alfa Romeo cars to this country. Decorative plating on steel, including bumpers, consists of bright nickel coatings applied over buffed copper deposits. Fiat boasts one of the largest and most modern automatic plating plants in Europe.

Sweden has accepted the processes from the United States and extensive use is made of the duplex nickel process in plating bumpers and automotive trim for Volvo and Saab cars. Standard thin chromium deposits are applied over the nickel although there is considerable promotional activity on the part of suppliers of American proprietary chromium plating processes. The acetic acid salt spray test is still used to evaluate plated parts, but the Corrodkote test is being considered.

The proprietary decorative nickel and chromium processes used in Holland are mainly those developed in the United States and made available through agents. There are also some domestic processes available. Now that Holland has started to produce its own automobile, the DAF, steps are being taken to establish suitable thickness standards. Accelerated corrosion tests such as the Corrodkote and CASS test are being investigated.

Metallurgical Progress in Canada

*By HAROLD J. ROAST**

Information from more than a score of laboratories and research departments, industrial, educational and governmental, indicates vigorous advances in all branches of metallurgy, from ore beneficiation to production of dislocations in whiskers, and from steel manufacture to atomic energy. (A-general)

SINCE A MAJOR PART of our wealth in Canada consists of metals, many metallurgical investigations are under way in our universities, governmental agencies and industrial plants. In fact, information for this report was received from 21 research centers. Much of it is fundamental – not, at the moment, having direct application to industry. Yet it ranges from dislocation theory to galvanized coatings, from ore leaching to stainless steel bathroom tile.

Ores and Tailings

A logical place to start is where the winning of metals starts. A new method for leaching lead ores has been perfected by Prof. F. A. Forward of the University of British Columbia, with the help of metallurgists of Sheritt Gordon Mines, Ltd. Starting with the ore – usually containing galena – the PbS is converted to $PbSO_4$ by hot H_2SO_4 under pressure, and the insoluble sulphate leached out with a cold aqueous solution of ethylene diamine or diethylene triamine. The soluble lead-amine complexes are then precipitated as basic lead carbonate by bubbling CO_2 through the solution. The amine is regenerated with CaO and the resulting $CaSO_4$ discarded.

Even though the leach contains many other metallic-amine complexes in solution, derived from the many minerals in the ore, only the lead is precipitated. For example, "pure" lead is produced from a silver-bearing galena, and by "pure" is meant less than one part silver per million.†

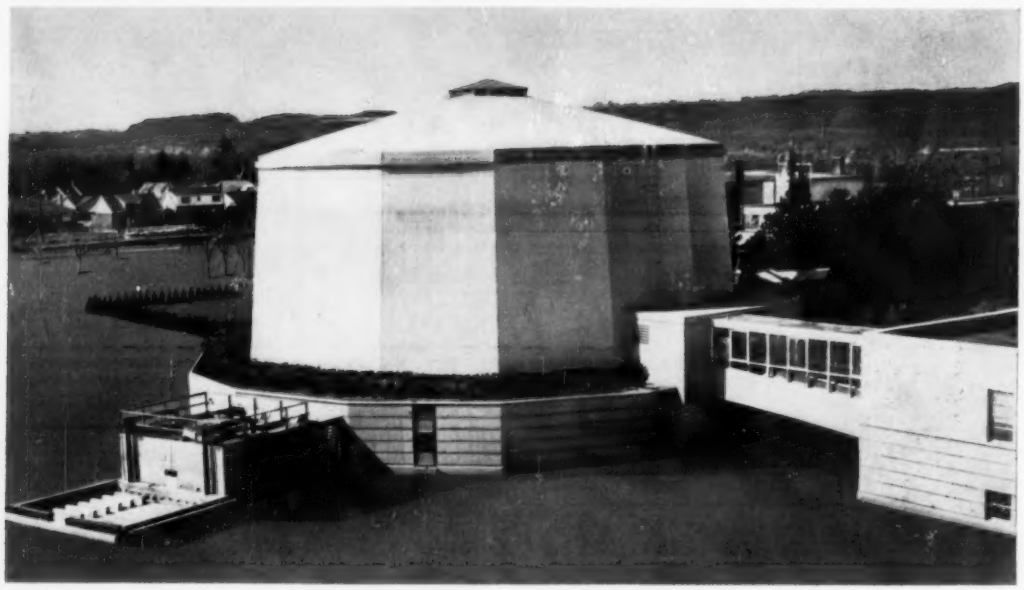
It may not be out of place here to mention other recent processes devised by Canadian metallurgists for ores and tailings, even though they relate to accomplishments rather than work in progress.

First is the roasting plant and electric furnaces installed at Kimberly, B.C., by Consolidated Mining & Smelting Co., for producing pig iron from a 25,000,000-ton tailing dump – a waste heap from their lead-zinc concentrator.

Next is the manufacture of high-grade iron

*Consulting Editor, *Metal Progress*, Ottawa, Ont.

†Professor Forward is no Johnny-come-lately in this general field of research. At the meeting of the Metallurgical Society of the A.I.M.E. at the National Metal Congress last October he was presented the John Scott Award "To the Most Deserving" by the City of Philadelphia – the fourth metallurgist so honored in more than a century. His achievement was the discovery of a leaching process for low-grade nickel ore.



Nuclear Reactor for Instruction and Research at McMaster University, Hamilton, Ont.

ore from the Sudbury nickel ores; International Nickel Co. has been operating such a plant since 1956 at Copper Cliff, Ont. The concentrate is magnetic iron sulphide (pyrrhotite); it is roasted to oxide in a "fluid bed" kiln, the nickel, copper and cobalt leached out, and the remaining almost pure magnetite (68%) sintered into pellets; it is said to be the world's highest-grade iron ore.

Third, a guarded announcement comes from Alcan (Aluminum Co. of Canada) that a pilot plant is successfully producing metal direct from bauxite, thus eliminating costly chemical processes for preparing highly purified Al_2O_3 for cell feed.

Finally, note should be made of a research program which has been completed by the Department of Mines, Ottawa, showing that tailings from a titanium ore can be used instead of fluorspar for thinning molten slag. This material containing ilmenite (iron-titanium oxide) is about one third the price of fluorspar; tests showed it to be an effective thinner and less corrosive to the usual basic refractories.

Steel Manufacture

Lively research into steel manufacture is indicated by work at the Canadian Department of Mines and Technical Surveys in Ottawa and at Atlas Steels Ltd. at Welland, Ont.

At Ottawa, desulphurization of basic steel is being studied by injecting lime, magnesium and calcium alloys into the finishing slag, prior to tapping. The investigators are correlating the sulphur level to the type of inclusion, the mechanical properties of the steel and its response to heat treatment. A related study is of ferritic cast steel, unusually low in sulphur and phosphorus, made in an electric arc furnace from "direct iron" (pure ore reduced by hot gas). The castings have very good tensile and impact values at subzero temperature.

Vacuum degassing and vacuum-steam degassing of 500-lb. carbon steel melts, poured into 4-in. slabs, have reduced hydrogen and oxygen content to about 1.0 ppm. and 30 ppm., respectively. Resulting changes in macrostructure and mode of solidification were correlated with tensile ductility and "fisheye-fracture"; fatigue and impact properties are being compared for the nondegassed, ladle-degassed and spray-degassed slabs, which are, in effect, castings 4 in. thick.

A variety of studies on steels of new and modified composition are continually under way at Mines Branch in Ottawa. Basic investigations involve extraction of carbides and other particles from the steel after various heat treatment and aging periods, and their identification as to composition and crystal structure. Small additions of Cb, Zr and Ti have been made to carbon steel and then rolled into plate.

Similar studies of the effect of uranium* on steel have already given some definitely interesting results, brought about by the addition of very small amounts of alloying metal. An age hardening, creep resistant Cr-Mo-V steel for large rotor forgings to operate at 1050° F., and a fine-grained, low-alloy vanadium steel having high ductility and toughness, especially suitable for propeller shafts, have also been developed.

Contrasting with the above is the work done at Atlas Steels, Ltd., which is primarily applied plant research and development, and directed largely toward stainless and toolsteels, the firm's major products. The staff metallurgical group is especially proud of the work done six or seven years ago, culminating in the continuous casting machine and the planetary mill for hot strip – the first of their kind to operate commercially in North America†, and kept in operation in the early years through costly and continuous study. In a single pass taking about 14 min., the slab is reduced 95%, from 2.5 to 0.125 in. thick. Currently vacuum melting and vacuum degassing techniques are under scrutiny.

In the research laboratory at Atlas, three major projects are now under way: *(a)* study of new stainless alloys, especially precipitation hardening analyses; *(b)* influence of variations in composition on the properties of ultra high-strength steels for aircraft and missiles; and *(c)* thermal fatigue of hot dies. The second mentioned has led to a 5% Cr analysis of superior qualities.

Light Metals and Alloys

Recent research at Aluminium Laboratories (Kingston, Ont., and Arvida, Que.) has been directed to strategic alloy systems, their fabrication and performance in service. Particular emphasis has been placed on basic studies on Al-Mg, with or without silicide, and Al-Zn-Mg, especially to establish those compositions which will give the best combination of good fabricating properties, strength, stress-corrosion resistance, weldability and reflectivity in sheet, plate and extruded forms. One result is an alloy with nominal composition 0.60 Mg, 1.00 Si, 0.60 Mn, 0.35 Fe, brought to the commercial stage as Alcan B 51 S. This alloy is suitable for a wide range of medium-strength engineering purposes.

Much work has been devoted to the continuous casting of thin strip by the Hazelett process. In addition, the older, conventional direct-chill casting process continues to be scrutinized in an effort to reduce stress-cracking during casting and to improve internal quality and surface structure.

Hydrogen is a troublesome element when dissolved in aluminum, as it is in steel. However analytical methods for hydrogen in both solid and liquid aluminum are not accurate and fast enough. Studies along this line have resulted in the "Dardel Initial Bubble" modification of the reduced-pressure method of analysis, and the more precise quantitative results have aided greatly in investigating the physical behavior of hydrogen in the solid metal, such as its rate and mode of diffusion and its accumulation in discontinuities, as well as the relations between hydrogen content and the number and nature of defects due to its presence in the metal.

Another matter receiving considerable attention at Kingston is the aluminum-silicon hypereutectic alloys. In addition to a low coefficient of thermal expansion, they are inherently more wear resistant than other aluminum-base alloys. However, their successful application as engine parts (pistons, for example) depends almost entirely on achieving a fine and uniform dispersion of the primary silicon in the metallurgical structure; the foundry techniques required to do this are not yet known.

Three main projects are also currently under way in the light alloy field at the laboratories of Mines Branch in Ottawa. The first – the effect of various foundry factors on the mechanical properties of light alloys – is to enable foundrymen and designers to make the best use of cast materials. The second is a study of the aging characteristics of aluminum with 10% magnesium, and is designed to reduce the susceptibility of these alloys to overaging and stress-corrosion. Thirdly, various magnesium alloy systems are being invesitgated in an attempt to explain, logically, the heat treatment of certain commercial alloys and to develop improved compositions.

Corrosion of the "corrosion resistant" metals aluminum, magnesium, zirconium and their

*Those with a bent toward history will enjoy rereading Clarence T. Patterson's article "The First Ferro-Uranium Made in America" in *Metal Progress* for June 1957. It describes "Electrite Uranium High Speed Steel", marketed during the 1920 decade, and his experiments with uranium as a deoxidizer and scavenger for the low-alloy structural steels.

†See *Metal Progress*, November 1954, p. 79.

strong alloys is a matter of especial importance to atomic reactors, so it is natural that the research metallurgists at Chalk River (Atomic Energy of Canada, Ltd.) are working on the "compatability" of these metals with water at extreme temperatures and pressures.

Special attention has been given to the Al-Ni system, and a wide range of zirconium alloys. The latter readily absorb hydrogen from aqueous environments, and when the solid solubility is exceeded, precipitates of acicular hydride form which can affect the mechanical properties. Current investigations are attempting to determine the mechanism by which hydrogen enters the metal; once this is known it may be possible to devise ways to prevent its entry.*

Work is also in progress on a new zirconium alloy with better mechanical properties than Zircaloy. An alloy of zirconium with 2.5% Cb, similar to that reported by the Russians, has adequate corrosion resistance under conditions existing in water-cooled power reactors and, after heat treatment, better mechanical properties than Zircaloy. Work is currently in progress to determine its fabrication properties and the effect of neutron irradiation and hydrogen pickup on its mechanical properties.

Alcan, at Kingston, has under way a long-term program to compile fundamental information about the mechanism of growth and the characteristics of the oxide film on aluminum. Pitting of aluminum alloys in various waters has been investigated for several years; samples of many Canadian waters have recently been brought to the laboratories and the corrosion of aluminum has been determined in them by a standardized pitting test. The influence of water velocity on pitting has also been studied with the object of increasing the use of aluminum pipelines in oilfields and mines and on construction sites.

Because of the importance of anodizing for architectural components and automotive trim, the various tests for the degree of sealing of anodic films have been appraised, and a preference has been given to the sodium sulphite immersion test because it is both rapid and discriminating. With its help, limits have been set for ions (such as phosphates) which are detrimental to the sealing process. Another program to improve sealing methods has produced a two-step technique comprised of a first seal in water followed by one in dichromate solution. This method requires less time than conventional water sealing and is more effective.

*Related studies are under way at the University of Alberta, in Edmonton, where the Zr-O-H ternary system is being intensively studied.

Welding

Mines Branch, Canadian Department of Mines and Technical Surveys, in Ottawa, has studied the joining of pipe by high-frequency induction heating, a project initiated by the Royal Canadian Navy as part of a program on the welding of pressure piping on naval vessels. It has been found that, when the temperature is correct, a good joint can not only be made at lower pressure, but the process is very rapid, requiring as little as 15 sec. for a butt joint in plain carbon steel tubes. However, for some of the alloy and stainless steels, a 10 to 15-min. post treatment may be necessary. For the latter, the same induction heating equipment can be used.

The advantages are threefold:

1. The operation lends itself to automatic control, once the equipment is assembled.
2. The metal at and adjacent to the joints is equivalent in properties to that produced by other welding methods.
3. It is easier to control weld contour by this new procedure than by fusion or flash welding.

The technique of "enclosed welding" for butt joints in concrete reinforcing bars has also been investigated at Ottawa. The adjoining ends are partially enclosed with a split cylindrical copper block, welded with a coated electrode low in hydrogen, and the slag collects between the bar and the copper block. The danger of cracking in hardenable steel grades is minimized because cooling rates are slow. It should prove to be a rapid and economical method for producing full-strength joints.

Welding of aluminum has long received much attention at the Kingston laboratories. Particularly, effort has been expended to adapt the gas-shielded metal-arc process to a welding machine for aluminum pipe. As a result, a versatile, portable pipe welder has been designed which will help to increase the use of aluminum pipe for carrying fluids of all kinds.

Inspection Using Ultrasonics

The Metal Physics Research Group of the Ontario Research Foundation has been studying the ultrasonic pulse technique. It is known that losses in energy attenuate the wave when an ultrasonic wave *(Continued on p. 150)*

Improved Metallographic Techniques in Nova Scotia

*By C. A. GODDEN**

Described are a vacuum deposition technique that aids the study of thin oxide films and a versatile mounting material, diallyl phthalate, which does not shrink from edges of the specimen. (M20; Al, 14-62)

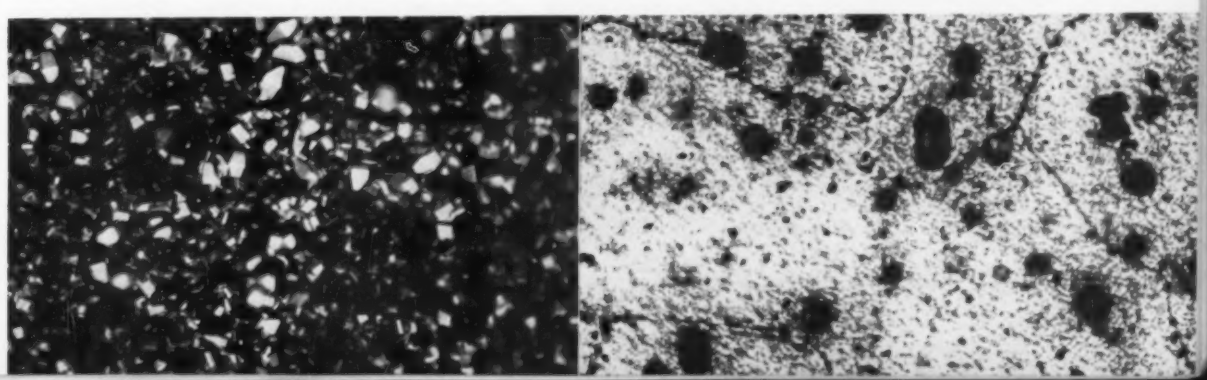
I—Metallic Films Aid Study of Oxide Coatings

EXAMINATION OF THIN OXIDE films on aluminum with an optical microscope presents difficulties when the films are to be photographed at high magnifications. The refractive index of aluminum oxide films is 1.56 and that of the immersion oil used with a high-power microscope objective is 1.52. This close similarity of refractive indices makes it difficult to obtain a clear image when examining a film of aluminum oxide at high magnification through immersion oil. Unfortunately, the refractive index of mounting plastic is also in the same range – 1.53 to 1.57. Thus, there is no contrast between it and the oxide.

An answer to the problem is to deposit a thin coating of metal over the oxide film. Figure 1 shows the corroded surface of 2 S aluminum with and without a thin film of aluminum. The configuration of the oxide crystals is clearly seen on the coated specimen.

Coatings are applied in a small vacuum coat-

Fig. 1 – Surface Views of Corroded 2 S Aluminum Alloy. Left: coated with a film of evaporated aluminum 1000 A. thick; Right: uncoated. Both are at 1000 × (oil immersion objective). On uncoated specimen the similarity of the refraction indices of aluminum oxide and the immersion oil (1.56 and 1.52, respectively) prevents study of oxide surface



*Department of National Defence, Defence Research Board, Halifax, Nova Scotia. Work reported here is part of Defence Research Board Project D-12-75-10-35. The author acknowledges permission of the Board to publish the article.

ing unit with the specimen located normal to the evaporating source. The amount of metal evaporated should be sufficient to cover the surface of the specimen with a layer 1000 A. thick. Films of this thickness cover the contour of the oxide film surface and outline the projecting crystals. With this technique, oxide layers on aluminum can be readily measured in cross section. In addition, some light is reflected back into the oxide film thus rendering the included particles clearly visible.

If the oxide film configuration is to be correlated with metallic structure in cross section, a coating metal should be chosen which will resist the etching reagent to be used. Gold, pallladium and rhodium are suitable. Where considerable exposure is required to record the maximum detail in the oxide film, a gold coating can be advantageously used. Its reflectivity is less, and photographs will be better.

II—Diallyl Phthalate as a Mounting Material

To retain the edge of a sample mounted for metallographic examination as perfectly as possible, plastic mounting material that does not gap or shrink is required. Our experience has also shown that it is best to use diamond polishing procedures and to employ a plastic mount filled with metallic flakes. If electrolytic polishing is planned, sufficient flake should be used to make the mount conductive.

Table I — Properties of Molding Resins

Resin	Post Molding Shrinkage	Polishing Characteristics	Chemical Resistance
Acrylic	Negligible	Fair	Poor
Melamine	Excessive	Good	Fair
Epoxy	Negligible	Fair	Good
Diallyl phthalate	Negligible	Good	Excellent
Phenolic	Excessive	Good	Good

Normally, shrinkage in the plastic mount occurs after it is removed from the press and continues over a period of days until equilibrium conditions are established in the cured resin. The resulting gap between the specimen and the resin traps polishing compounds, etchants and generally results in a damaged or stained specimen edge. Because the study of thin oxide films on aluminum requires good edge definition and preservation, a mounting medium with negligible post molding shrinkage is required.

Properties of several resins are outlined in Table I. After testing many resins, diallyl phthalate prepolymers were found most suitable.

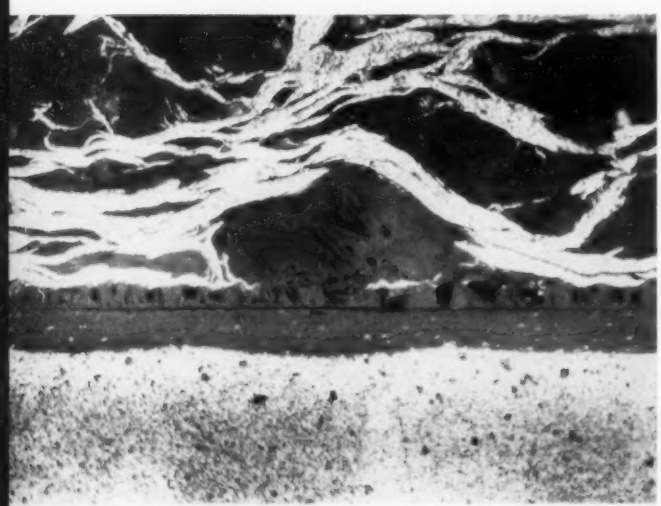


Fig. 1 — Cross Section of Corroded 2 S Aluminum Alloy Mounted and Polished at a 20° Angle so That the Width of the Oxide Film Exposed in the Sample is Three Times the True Thickness. Diallyl phthalate filled with aluminum flakes makes an excellent mounting medium because it does not shrink away from the specimen surface. Aluminum flakes improve polishing characteristics and permit electropolishing. 500 ×

Mounting Procedure

To develop fully the high chemical resistance and extremely low post mold shrinkage properties of diallyl phthalate, it should be properly processed. Preparation of mounts is simple and follows general practice. Full curing is achieved between 130 and 160° C. (266 and 320° F.). It has been observed while making 1-in. molds that 145° C. (293° F.) with a ram pressure of 2500 psi. and a curing time of 6 min. is optimum. Since most of the shrinkage takes place during the curing cycle, it can be prevented by applying full pressure until the sample has beel cooled to 65 to 70° C. (about 145° F.). This insures full stability of the mount.

Using this procedure, aluminum specimens with oxide films from 1000 A. to 10 microns thick were mounted. Good edge preservation was obtained with no visible gapping observed at magnifications of 1000 × either immediately after mounting and polishing or after six months storage. The procedure also eliminated staining of the specimen by trapped etchants. 'Another advantage of diallyl phthalate prepolymer is that in its uncured form it is soluble in various organic solvents. Dissolved in methyl ethyl ketone or acetone, it can be used to impregnate the surface of a specimen which is porous or friable. After evaporation of the solvent, the specimen can be mounted normally.

Electropolishing

Diallyl phthalate, when filled with sufficient conductive fillers such as aluminum flake, forms an excellent mounting medium for electropolishing. Electrical conductivity with the specimen is positively assured through the mount. The chemical inertness of diallyl phthalate compounds make them particularly suitable for this purpose. Its use in perchloric acid electrolytes appears permissible, but an individual safety check would be in order.

By using this resin as a mounting medium, we have been able to obtain good quality photographs of the aluminum oxide layers. Figure 1 shows a cross section of an aluminum oxide film in which the aluminum specimen was chemically darkened to decrease photographic contrast. Figure 2 shows cross sections of nickel-plated copper mounted in diallyl phthalate and a phenolic mounting compound.

Fig. 2 – Micrographs of Nickel - Plated Copper Demonstrate Advantage of Diallyl Phthalate as a Molding Medium. Top: diallyl phthalate is in close contact with specimen surface; bottom: bakelite has drawn away from specimen leaving a gap. 1000 ×

Short Runs

Stress-Relieving Large Weldments by Radiant Heating

*By TOM BISHOP**

IN ENGLAND, halves of turbine casings (see Fig. 1) are manufactured by welded construction. After welding, these half-turbine-casings (which measure about 21 × 17 × 18 ft.) are stress-relieved by radiant electric heating.

Due to the amount of metal and the complicated nature of the structure, calculations indicated that a casing could be stress-relieved by 68 single-phase radiant heating elements, each of 7½ kw. rating. The heaters were arranged within the casing to ensure even heating throughout the structure; each heater could be individually controlled.

At the start, the casing was placed on a firebrick base, and most of the heating elements were suspended vertically inside (although a number were mounted on the floor at predetermined strategic points). After covering the open top with a ½-in. steel plate, the whole structure was encased in thermal insulation to a depth of 6 in. Next, 42 thermocouples were arranged about the casing, and connected to seven 6-point graphic recorders for temperature measurements. Thus, average conditions throughout the whole casing could be recorded during the heating operation, enabling the workers to adjust individual heaters to maintain uniform heating.

When the temperature reached 1200° F., the power input was reduced to keep the temperature constant while the casing soaked for 3 hr. Then, the heaters were turned off and the casing was cooled to ambient temperature.

Although the heaters were controlled manually in this instance, the arrangement is suited for automatic control.

*Consulting Editor, *Metal Progress;* John Miles & Partners (London) Ltd.

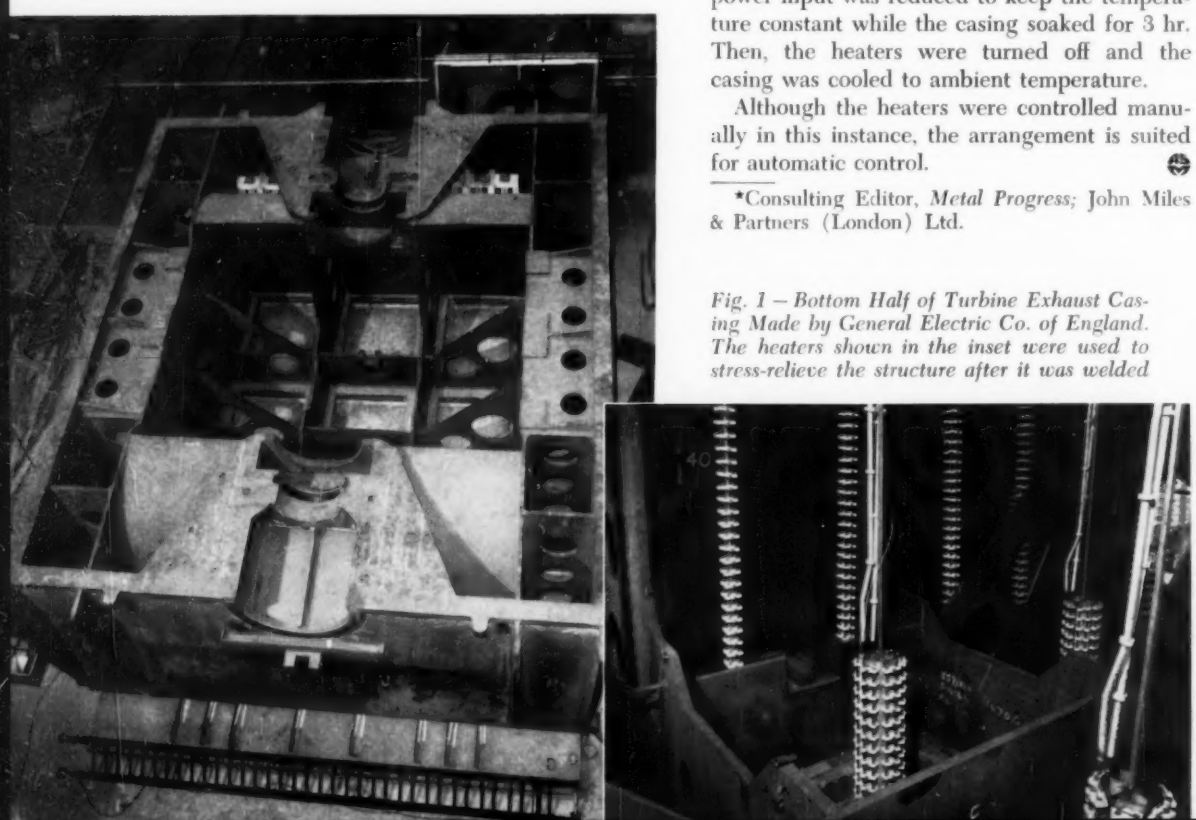
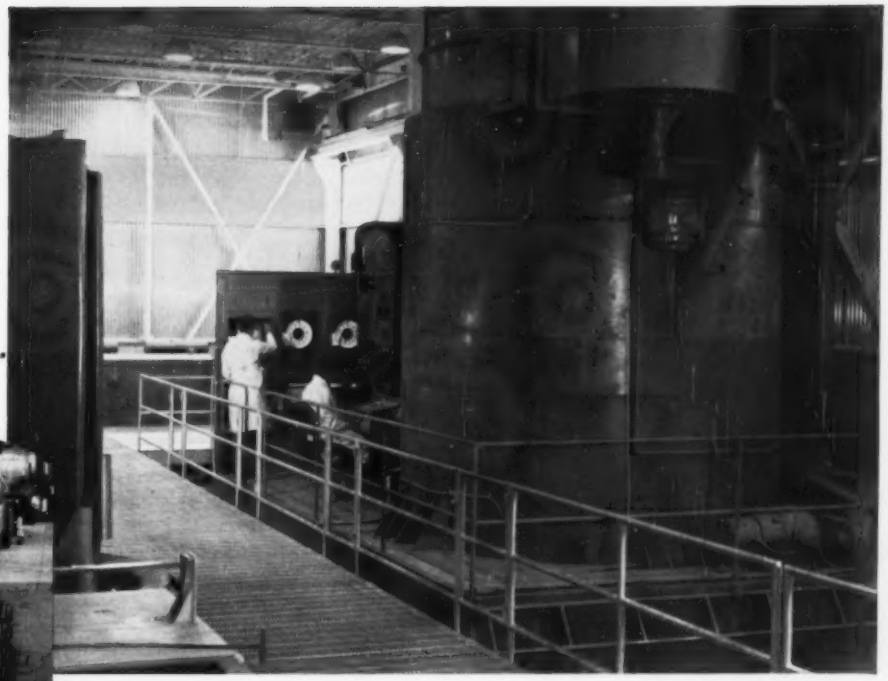
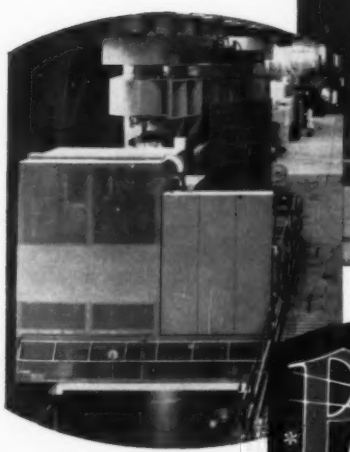


Fig. 1 – Bottom Half of Turbine Exhaust Casing Made by General Electric Co. of England. The heaters shown in the inset were used to stress-relieve the structure after it was welded

At The Marquardt Corporation's Ogden Division . .





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LETTERS TO THE EDITOR

Two Fundamentals of all Metallurgical Operations

The Editors are glad to publish this note from Prof. Albert M. Portevin, dean of French metallurgists. He wrote regular letters to *Metal Progress* during the first decade of its history. He is a Member of the Institute of France, Bessemer Medalist of the British Iron & Steel Institute, Honorary Member of the American Society for Metals, and Associate Member of the U.S. National Academy of Sciences.

PARIS, FRANCE

In this age wherein specialization is becoming more and more intense, it is salutary to the spirit to attempt to relate various technical processes, even including the most ancient ones, to some general idea or some basic principle. This is not only satisfying to the spirit, but also fertile in suggesting new applications and pointing the road to further improvements. One can even consider that this is beneficial to the mind if it balks somewhat the cult of specialization, sometimes considered as a fundamental condition of modern research. For, as Louis de Broglie in "La Méthode Dans Les Sciences Modernes" truly says, "Specialization narrows the scope, makes fruitful comparisons and analogies more difficult, and may eventually compromise the future of the mind."

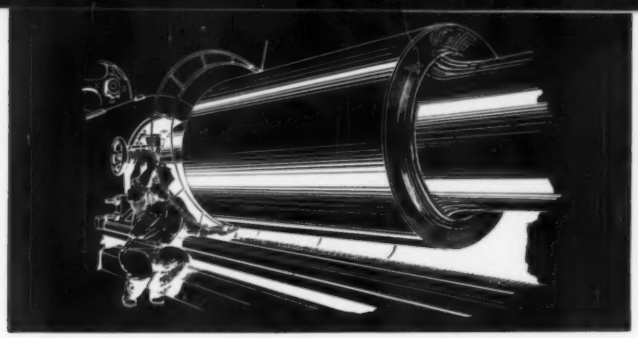
An example — which of course does not pretend to be novel — is to consider metallurgical operations which involve reactions between two phases, be they liquid, solid or gaseous. The kinetics of these reactions are of enormous importance to their commercial utilization, and the three most important factors which control the speed are (*a*) temperature, (*b*) contact area and (*c*) agitation which multiplies the extent of the surfaces in contact. Their importance results from the circumstance that reactions between phases require that atoms or molecules of gas or other elements must diffuse towards or away from the point or surface of contact. Unless such atomic diffusion occurs, be it in solid, liquid or gas, the reaction promptly ceases.

Now, the extent of contact or area of interphase surfaces can be increased greatly by subdividing the contacting materials to the point of an *emulsion* of liquid or gaseous phases or to a fine *dispersion* of a solid phase in a liquid phase. This readily explains the great difference in the results of tranquil fusion in the openhearth furnace — taking hours to refine a bath of steel — and the Ugine-Perrin process* wherein metal from an electric furnace is slowly poured into a molten slag which emulsifies it and in a few minutes effectively desulphurizes and deoxidizes the steel. A second instance is the casting of steel in vacuum, primarily to remove hydrogen. If a ladle of molten steel is placed in a vacuum chamber, the dissolved gases can be pumped off but slowly. If, however, as recommended by Spire, an inert gas like helium or argon is bubbled through the metal, agitating it considerably, adequate degassing occurs in about 15 min. It may even be sufficient to place the ingot molds in a vacuum tank and teem hot metal through a lock; its agitation in the stream brings hydrogen to the surface of the bubbles where it is sucked out effectively†.

Likewise during the decarburization of molten pig iron there is a great difference in speed in a bottom-blown bessemer converter, where there is violent agitation and close contact between air and metal, and in the simple oxidizing fusion on a hearth. *(Continued on p. 128)*

*Professor Portevin first discussed these principles in *Metal Progress* for February 1933, and in April 1949 presented an extended description of the commercial applications of the Ugine-Perrin process in postwar France, Poland and India.

†See *Metal Progress*, September 1959, p. 111 and January 1960, p. 117.



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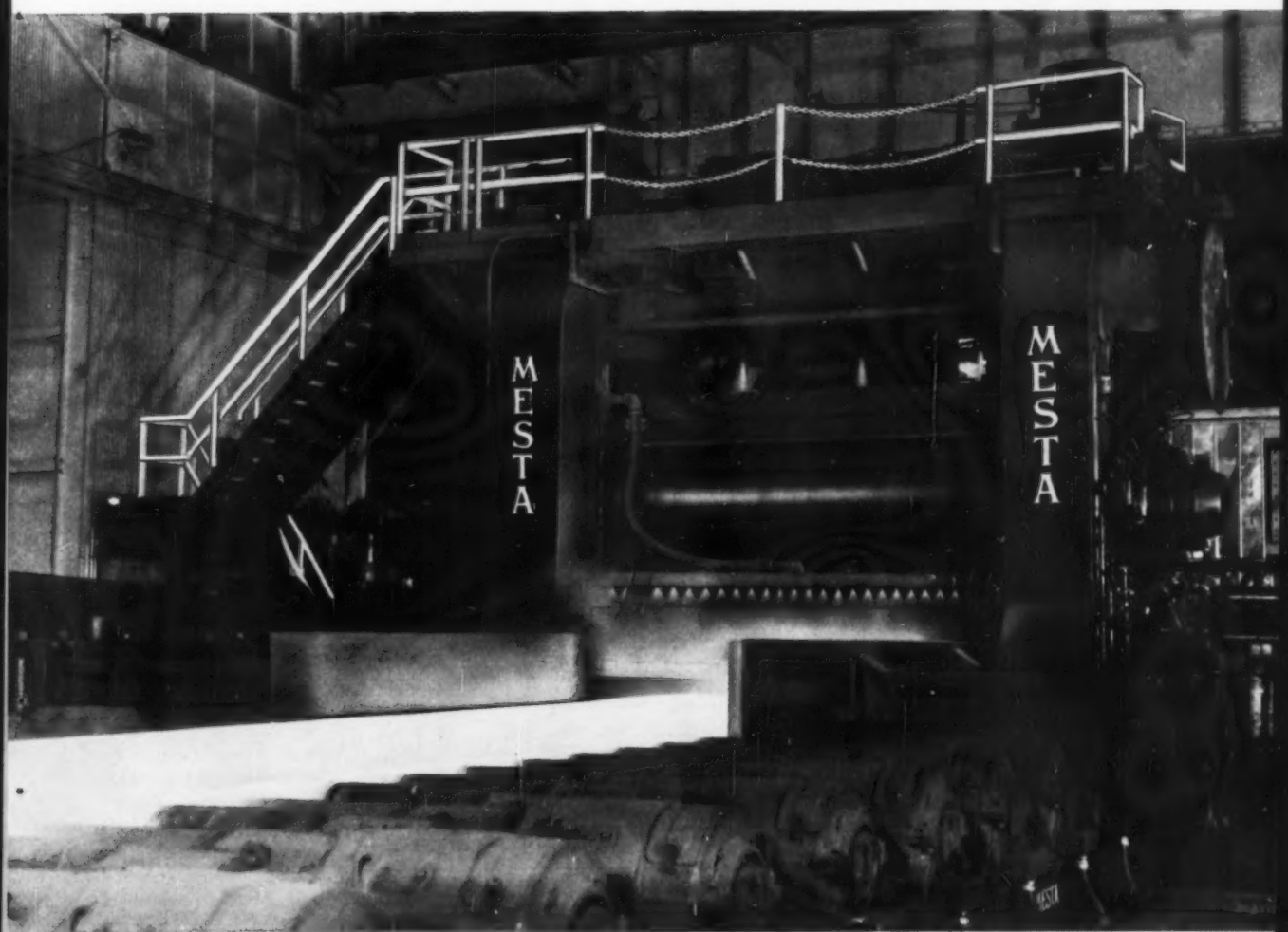

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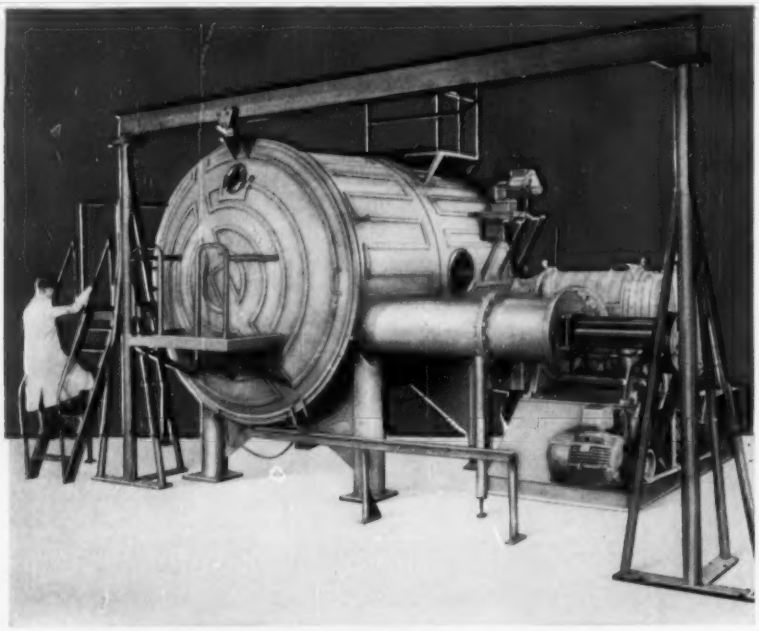

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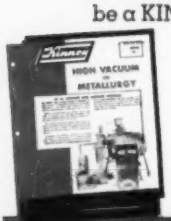

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Circle 445 on Page 48-B

Letters . . .

Again — to agitate a solid phase in a liquid it is advisable to pulverize it and blow it into the fluid in an appropriate stream of gas. An example is the Allard process for desulphurizing pig iron by blowing of inert gas. Another is the carburizing of magnesium with powdered calcium carbide.

In fact the role of fineness — of dispersion of phases — is even more important than the two other factors, temperature and agitation. For a good example of this let us turn to the field of refractories — specifically mullite, $3Al_2O_3 \cdot 2SiO_2$ having great resistance to erosion and heat. If a mixture of 72% Al_2O_3 and 28% SiO_2 is slowly cooled from the melt, the equilibrium diagram shows that crystals of corundum (Al_2O_3) start to form at about 1925° C. (3490° F.), and that at 1810° C. (3290° F.) a peritectic reaction should occur isothermally between the solid corundum and the mother liquor, converting the entire mass into crystals of mullite. Unfortunately, this excellent refractory cannot be synthesized in this manner. At the very start of the isothermal reaction the sheaths of mullite crystals forming on the already-solid corundum separates the reacting phases — solid corundum and mother liquor. Diffusion of the Al_2O_3 nuclei is at a rate approaching zero. On the other hand, macrocrystalline aggregates of mullite have been made by Taylor and Williamson starting from very finely ground alumina and quartz, compacted and fired by the metal powder processes. In this process the fineness of the particles becomes a prime requisite.

Similarly, Stohr and Klemm have reported that homogeneous solid solutions of silicon and germanium could not be obtained from melts, but only would result from a repeated program of pulverization, compacting and sintering.

It is evident that *fineness* of the particles plays the preponderant role in these reactions of powder metallurgy wherein vibration or mechanical or magnetic agitation of the particles or phases is out of the question. Sometimes alternating magnetic fields may replace or supplement the thermal agitation of atoms induced by raising the temperature.

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Letters . . .

are by no means novel, they may be matters for reflection and be susceptible of fertile applications.

ALBERT M. PORTEVIN
Professor of Metallography
Ecole Central

Brittle Failure of Strong, Tough Steel

JOHANNESBURG, SOUTH AFRICA

The several papers discussing brittle fracture of high-strength steels in *Metal Progress* last August properly are divided into two classes — *tests* to evaluate the danger and *nature* of the danger.

Without going into detail, I would submit that a simple *test* is still to be discovered. Whether it could really be simple is debatable, if one agrees to the following requirements:

1. It should be as simple as possible.
2. The test piece should not need to be cooled to a very low temperature range.
3. It should involve as fast rates of loading and as great a local stress concentration as possible.
4. The specimen should be fairly massive so as to cover the independent variable of size.
5. The specimen should carry a given internal stress imposed by some means or other. It should be possible to vary this internal stress.

As to the *nature* of the phenomenon of brittle fracture, the authors in *Metal Progress* did not call attention to the striking similarities and equally puzzling differences between temper brittleness of certain alloy steels and brittle fracture of "tough" mild steel. I venture the statement that an acceptable theory will eventually explain both phenomena satisfactorily. A tentative theory has been formulated by the writer and presented in the *Journal* of the South African Institute of Mining and Metallurgy, July 1960, p. 709.

Meanwhile, what should the purchaser require in the steel for safe operation at low temperatures? The following advice can be given as regards mild steel:

1. Use mild steel produced by a steelmaking process which drives the phosphorus to lowest limits and

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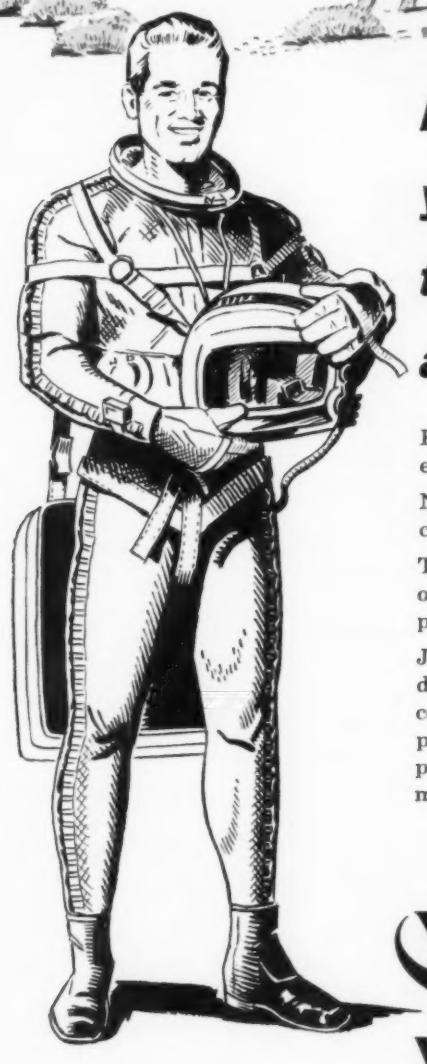

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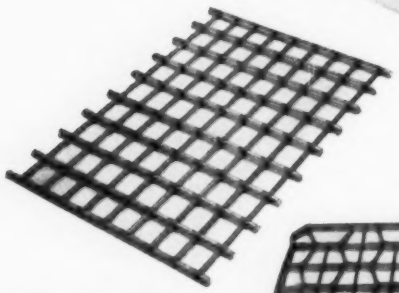

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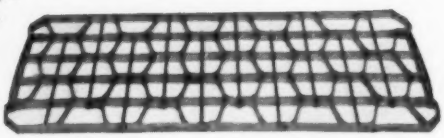

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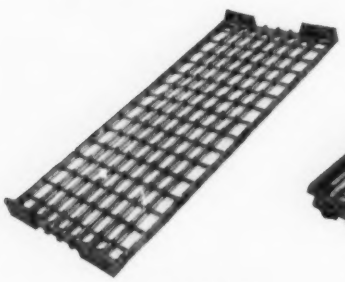

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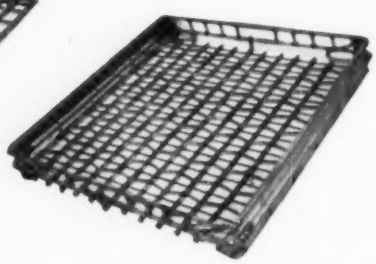

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Letters . . .

minimizes oxygen and nitrogen content.

2. Use an aluminium-killed steel for fine grain.

3. Use a steel with more than four times as much manganese as carbon.

4. Demand low finishing temperature after hot work.

5. The plate should be in the normalized condition.

Design of the part or structure also is most important. Perhaps it is not amiss to repeat well-known warnings, such as to avoid sharp corners and notches, to use nothing but approved welding techniques and the most skilled and conscientious welders, and finally to relieve internal stresses in the structure.

As to temper brittleness the following practices will avoid most of the trouble:

1. Use an alloy steel with sufficient hardenability so the piece is martensitic to the center after quenching.

2. Molybdenum additions are the usual curative for temper brittleness. Special attention to composition is necessary for parts which have to be reheated after quenching and tempering (as during nitriding) or which operate in the temperature range wherein "sensitivity" is acquired.

3. Steels without molybdenum should be quenched and then tempered at 1150° F. for several hours.

4. Otherwise put enough vanadium into the analysis for pronounced secondary hardening.

C. E. MAVROCORDATOS
Acting Head
Department of Metallurgy
University of Witwatersrand

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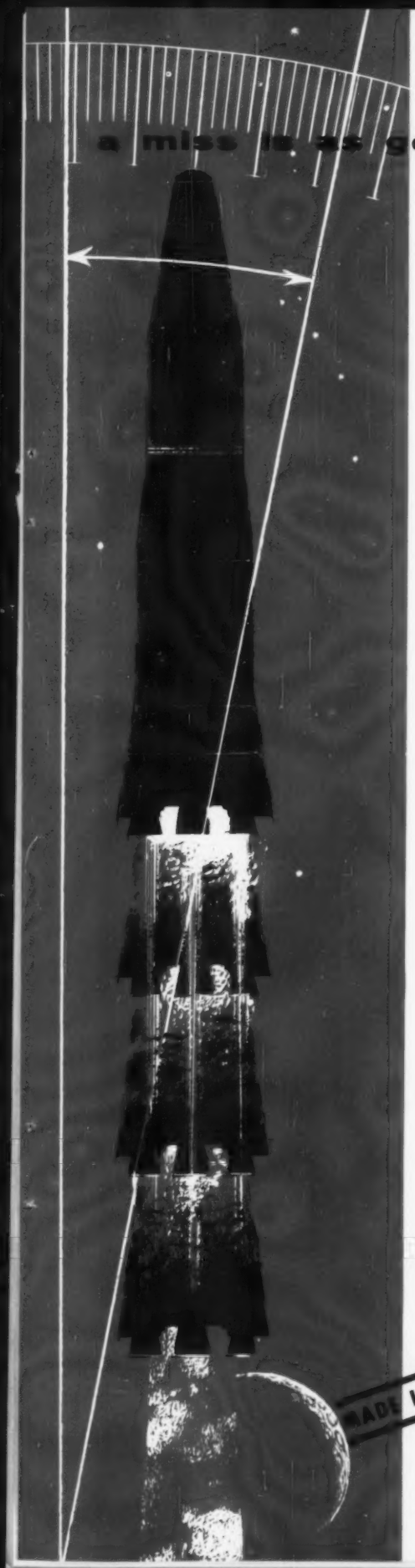
URBANA, ILL.

I am prompted to write on a subject which has troubled me for some time, namely, the relatively scanty information provided in the annotations in A.S.M.'s *Review of Metal Literature*. They do not compare with the wealth of detail given in the *Metallurgical Abstracts* of the British Institute of Metals.

As a person who attempts to keep abreast of current literature, I would say that it is not so much a matter of obtaining a reference, but of hav-



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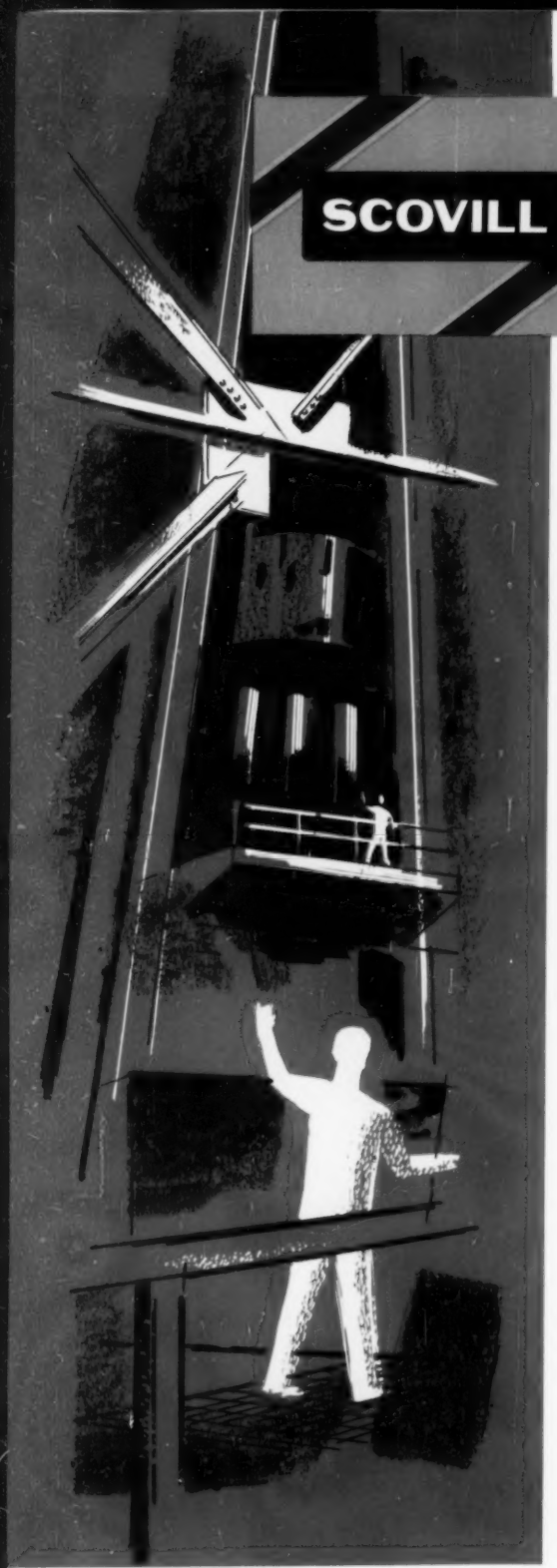

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Advanced quality-control procedures — insure dependable UNIFORMITY in all Scovill Mill Products specifications . . . order to order and lot to lot. They promise more accurately dimensioned, finer quality mill products essential to efficient high speed fabrication. Quality-control is a full-time job at Scovill, and the results are evident to fabricators in their own higher production speeds, minimum tool and machine adjustments and superior quality of finished products.

Advanced inspection equipment and methods — There are many inspection stations along each of the Scovill production lines for Brass strip and sheet, rod, wire and tube. In addition, samples of alloy billets and bars, as well as of finished mill products, undergo detailed inspection and test procedures in Scovill's Metals Research laboratories. Brass Mill Products that pass these rigid inspections and tests are considered by many to be the finest in the World.

Advanced packaging — Unique Scovill packaging methods protect quality, finish and condition, make it easier for fabricators to warehouse, handle and use Mill Products. Time- and cost-saving innovations such as extra-long-length coils of strip, self-feeding wire "dispenser" drums, special long lengths when required in tube mill products, are available to fabricators who need them.

Make Scovill a part of your competitive team, let us contribute our wealth of experience and ultra-modern equipment to the success of your NEW products and production plans.

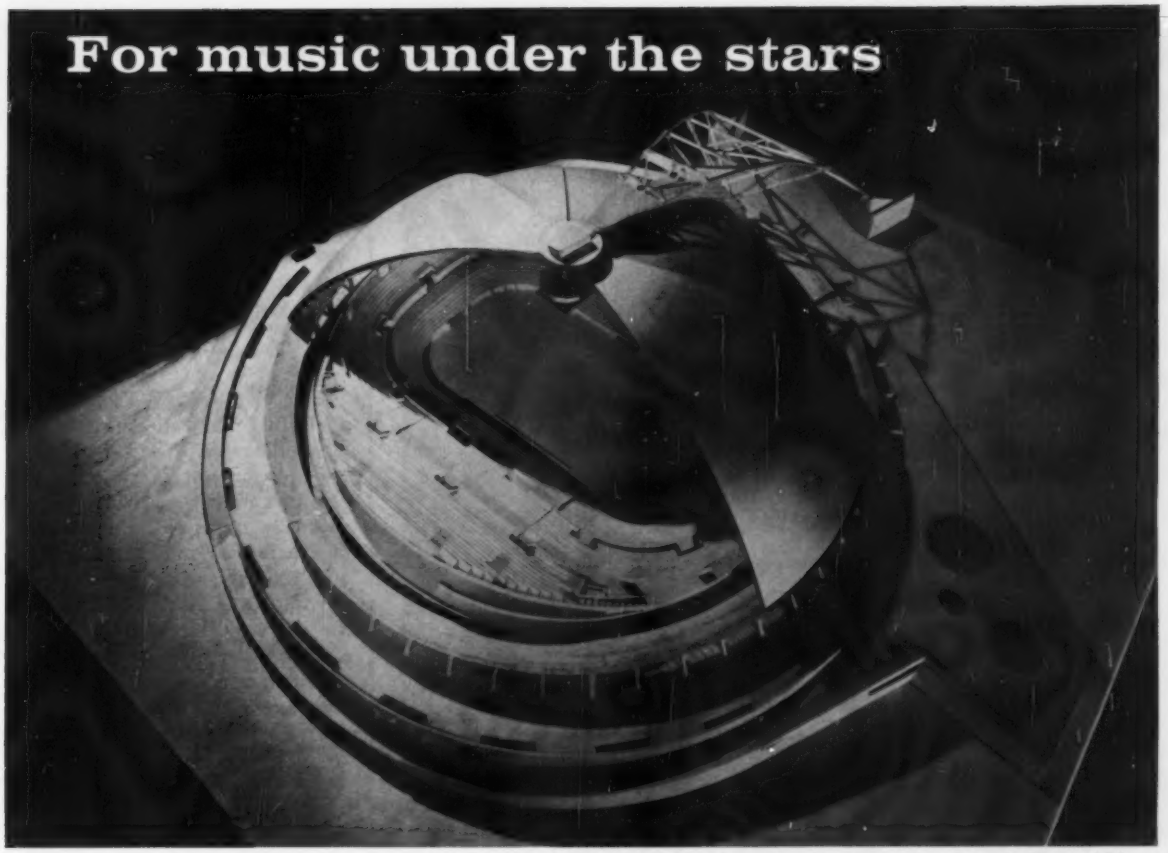
SCOVILL MANUFACTURING COMPANY
Mill Products Division, 99 Mill Street, Waterbury 20, Conn. Phone PLaza 4-1171

MADE IN USA
. . . and made better to bring out the BEST in your products

7SC60

MILL PRODUCTS

For music under the stars



Dome of Pittsburgh Auditorium, in partly opened position, shows stadium within.

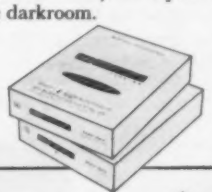
The 400-foot rollback dome of the new Pittsburgh Auditorium is supported by one huge welded cantilever backwork. Welds were proved sound by radiography.

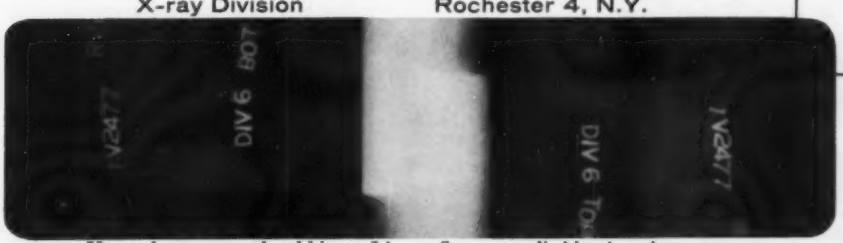
The "leaves" of the great dome over Pittsburgh's new auditorium move on a circular track turning on an overhead pivot. There are no interior supports. When the dome swings open, the anchors of the backwork holding it up are under about 4,000,000-lb. tension, the buttress under 7,000,000-lb. thrust. Every weld in the system is critical.

To assure the integrity of all welds, U.S. Steel's American Bridge Division radiographed them using Kodak Industrial X-ray Film. This radiographic inspection provides a permanent record of the soundness of the welds.

If you would like to learn more about radiography in terms of your business, talk it over with an x-ray dealer, or write us for a Kodak Technical Representative to call.

GOOD NEWS! Kodak Industrial X-ray Film, Type AA and Type M, is now available in the new, convenient Ready Pack. Each sheet—sealed in a light-tight envelope ready for exposure—stays clean. After exposure a rip strip on the envelope makes it easy to open in the darkroom.





X-ray shows a sound weld in an I-beam flange supplied by American Bridge Division of the United States Steel Corporation.

EASTMAN KODAK COMPANY
X-ray Division Rochester 4, N.Y.

Kodak
TRADEMARK

Circle 450 on Page 48-8

Want to strip "unstrippable" coating?

ask Oakite

OVER 50 YEARS CLEANING EXPERIENCE • OVER 250 SERVICE MEN • OVER 160 MATERIALS

Even tough EPOXY FINISHES peel off in Oakite STRIPPER S-A

Burn off an epoxy finish from a reject as a last resort? Not at all necessary. Oakite STRIPPER S-A strips metals clean. That's true for multiple coats as well as single coat epoxy finishes. Look at STRIPPER S-A's record:

- *A 3/16" thick coating built up from layers of epoxy coating and wrappings of fiber glass was stripped from gun barrels by overnight soak in Stripper S-A. Everything tried previously had failed.*
- *Brass plated steel parts were stripped of their epoxy finish in matter of minutes.*
- *Workholding spindles and racks laden with at least 10 coats were stripped to bare metal by a short soak. Paint hooks formerly burned clean are now soaked clean instead.*

This powerful stripper is safe for all metals except zinc and magnesium. And it's safe to the user, since it works cold . . . has no flash point . . . rinses with water.

STRIPPER S-A is but one of a long list of superior strippers by Oakite. Some are specially formulated for use on steel . . . aluminum . . . other metals. Some for removing lacquers . . . tough synthetic finishes. Still others are designed especially for removing paint from vertical surfaces. Whatever your paint-stripping problem—Oakite is bound to have the answer. Ask your local Oakite man or send for paint-stripping bulletin F-7893. Oakite Products, Inc., 34E Rector Street, New York 6, N. Y.

it PAYS to ask Oakite

OAKITE SCIENCE

over 50 *Est. 1909* *years' leadership in industrial cleaning*

Circle 451 on Page 48-B

Letters . . .

ing an adequate summary of it in abstract form for permanent use.

I also feel that abstracting and information searching is one of the most important of the A.S.M. activities, and is worthy of the attention and expense needed to make it truly first-rate.

MARVIN METZGER
Professor of Physical Metallurgy
University of Illinois

EDITOR'S REPLY — There is no doubt that informative abstracts are highly desirable. The biggest stumbling block of course is cost. (Witness the present price of *Chemical Abstracts*, probably the most informative in the world, at something over $900 a year to nonmembers of the American Chemical Society.) In the past, the *Review of Metal Literature* has been free to members of the American Society for Metals, and in the future a nominal charge of $5.00 per year will be made.

Excellent though *Chemical Abstracts* may be, finding the desired information in the volumes is an almost overwhelming task. The Decennial Index, now in preparation, will consist of 19 huge volumes! Likewise, there is a discouraging lack of promptness in the indexes; the index for the 1958 volume has just been published — a lapse of almost two years.

As a result of a five-year research at Western Reserve University, financed by the American Society for Metals, we believe we have solved the problem of greatest difficulty in *finding* information *thoroughly* and *promptly*. Our new A.S.M. searching service is designed to provide indexing in the same depth of detail as the informative type of *Chemical Abstracts*. It also provides the indexing immediately — within two weeks of receipt of publication in the Cleveland office. In other words, the brief indicative annotation published in the *Review of Metal Literature* is no criterion of the detail and discrimination provided in the operations that index and encode abstracts of current metallurgical articles. Our objective is to insure that all pertinent information on a specific subject or question is retrieved, even though it may not be evident even in a lengthy digest such

Tool Steel Topics

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

Export Sales: Bethlehem Steel Export Corporation

Plastic grille for air conditioner molded IN A BREEZE with Lustre-Die

This plastic grille for an air conditioner was molded at the rate of one per minute by Midwest Plastics Corporation, Wichita, Kansas. Using a die made of Lustre-Die tool steel, they produced a perfectly formed grille, with a high sheen. The grille measures 21½ x 15 in., and is ½ in. thick.

Why Lustre-Die is ideal for plastic molders

Lustre-Die tool steel is ideal for plastic molders because it can be put right to work, without the need for heat-treatment. It's easy to machine, and it polishes beautifully . . . making possible an eye-appealing sheen on finished plastic parts.

Lustre-Die is an electric furnace steel. It has a well-balanced basic analysis. By adding a special alloy fortification, which increases its depth of hardenability, its fine mechanical properties are further improved. Because Lustre-Die is heat-treated in the mill by means of oil-quenching and tempering, it comes ready for machining and polishing. It is also carefully controlled during manufacture to insure freedom from porosity.

You can always count on a fine molding job when you use Lustre-Die. But don't take our word for it. Put Lustre-Die to work in a trial run. Your Bethlehem tool steel distributor can supply you.

BETHLEHEM TOOL STEEL ENGINEER SAYS:

Watch Out for Abrasion Caused by Scale

When punch-press operators are occasionally unable to obtain the required sheet stock in the usual cold-finished form, they substitute hot-rolled stock. However, this causes the service life of the punches and dies to drop to one-half or one-third of normal, or less. This result is largely due to the abrasion of the scaled hot-rolled surface on the cutting edges of the tools. Determining whether such a substitution is economical depends upon the results which are expected, and the cost, of each individual job.

One frequently hears the question: "What can be done in tooling to avoid this decrease in production?"

When punches and dies are normally made from water-hardening carbon tool steel (W-1 or W-2), or from manganese oil-hardening steel (O-1), the shortening of tool life can be avoided by changing to a high-carbon high-chromium tool steel, such as Bethlehem Lehigh II (D-2). This change usually overcomes the disadvantage of using the hot-rolled scaled stock.

However, if high-carbon high-chromium grades are already being used, there is only one method by which an appreciable improvement can be realized—the use of special heat-treatment operations. Typical treatments are short-cycle hardening, and nitriding. Complete details regarding these types of treatment may be obtained by writing Bethlehem Steel Company, Bethlehem, Pa.

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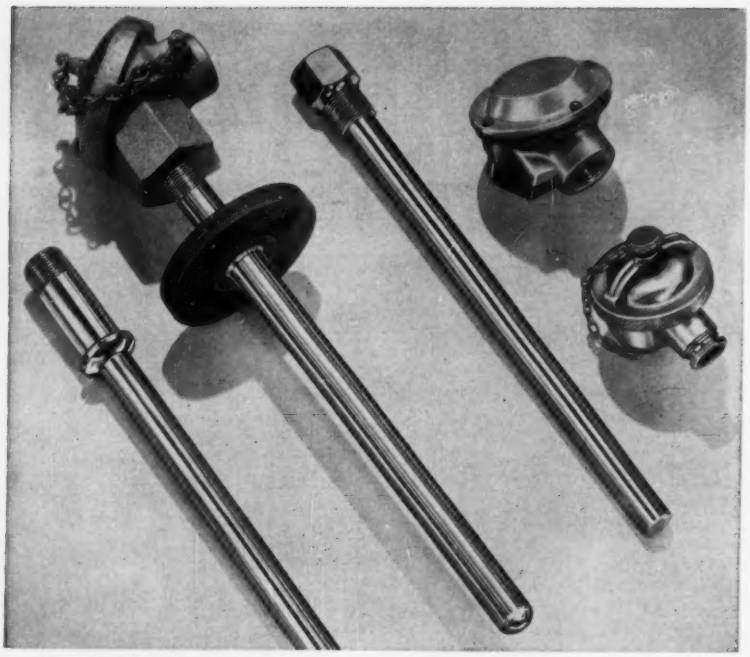


Thermocouple Assemblies For Every Industrial Use

Thermo Electric's base metal thermocouple assemblies give consistently reliable temperature readings for ranges between —300°F. and +2200°F. We specialize in solving problems caused by chemical attack, pressure and installation difficulties . . . and offer the most complete variety of standard thermocouple assemblies in the industry. See our new 16 page catalog for the many types available.

Thermocouples

Single and multiple junction thermocouples are made of all standard thermocouple materials and gage sizes. Ceramic insulated, metal sheathed "Ceramo-Couples" are used most effectively for extended life at high temperatures or for sub-zero conditions where condensation is a problem. These temperature sensing elements have excellent resistance to moisture, petroleum products, chemical action and abrasion, and are often used without additional protection tubes. The wires used in all these thermocouples are drawn, annealed, insulated and calibrated in our own wire mill under Thermo Electric's high standards for mechanical and thermoelectric qualities.

Thermowells

The selection of over 5700 standard Thermowells includes bar stock or built-up construction, test wells and extra sensitive wells; and a variety of mounting fittings and flanges. Many construction materials available—all wells are pressure tested.

Connection Heads

Choose from six different types, including heavy duty cast iron heads, lightweight aluminum heads, and quick-opening heads. All weather proof—many sizes.

Write For New Catalog E-16

Our Thermocouple Catalog has complete information, simplified ordering instructions for all assemblies and components, and a Thermowell Material Guide for hundreds of industrial applications.

Thermo Electric CO., INC.
SADDLE BROOK, NEW JERSEY

In Canada: THERMO ELECTRIC (Canada) LTD., Brampton, Ont.

Circle 453 on Page 48-B

Letters . . .

as prepared by the British Institute of Metals.

We plan, therefore, to spend the most of our available effort and money in analyzing *all* documents in the metallurgical field in this depth of detail. This detailed analysis is encoded on magnetic tape for machine searching. The additional intellectual effort of putting these so-called telegraphic abstracts into English would not be prohibitively large, but the clerical work, typing, and especially the publication costs, would skyrocket.

The A.S.M. funds available for abstracting, indexing, and literature searching are naturally not unlimited, and many hundreds of thousands of dollars have already been expended in services provided to our members which have not been reimbursed. Our first goal now is to put the A.S.M. searching service on a self-supporting basis. Once this has been accomplished – and we think it will be by the middle of the 1960 decade – there is no reason but what we can then bend our efforts toward providing better and more informative published abstracts.

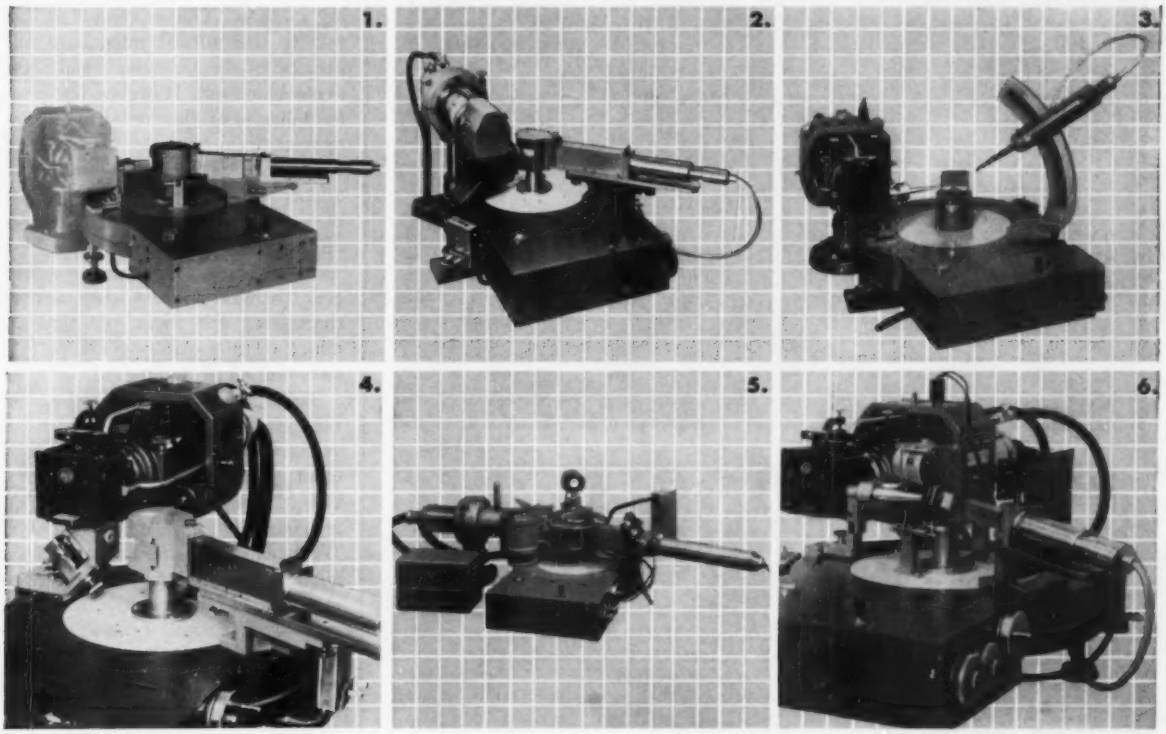
More on Oil-Water Quenchants

CLEVELAND, OHIO

In reference to the article "Modern Quenching Techniques Make It Easier to Heat Treat Steel", *Metal Progress*, October 1960, p. 101, I would like to mention our experience at Warner & Swasey with water-oil emulsions. On p. 105 the second paragraph in the second column states: "Manufacturers warn against the use of water-oil emulsions as a means for obtaining quenching rates between those of water and oil. Such solutions have no effect other than to prolong the first two states of quenching – and, from a metallurgical standpoint, these two stages should be shortened rather than prolonged."

We at Warner & Swasey have used water-oil emulsions for about five years. In 1954, we ordered a Tocco Motor Generator Unit with two field stations, the larger of which contains 1000 gal. of quench-

X-RAY DIFFRACTION AND SPECTROSCOPY



1. Counter Tube Diffractometry. 2. Spectroscopy. 3. Single Crystal Studies. 4. Spectroscopy of Small Areas. 5. Vacuum Spectroscopy of Light and Heavy Elements. 6. Studies of Orientation.

VERSATILITY!

RCA's horizontal goniometer performs 6 functions

Unusual versatility is an important distinguishing characteristic of RCA's X-Ray Diffraction and Spectroscopy Equipment. This versatility is graphically demonstrated by the horizontal goniometer which can perform six different functions merely by adding accessories, as illustrated above.

RCA X-Ray Diffraction and Spectroscopy Equipment offers many other outstanding features which make it one of today's most specified lines. For example, the DC regulated and filtered power supply; the option of mounting two tube stands on the Crystalloflex IV; a kit which permits conversion from diffraction to spectroscopy in minutes; and the new vacuum spectrometer for analysis of light and heavy elements. For those engaged in film studies of all kinds, the RCA Table Model Crystalloflex II can be bought, complete with cameras, for as little as $4000.

A NEW LEASING PLAN now makes it possible to obtain all RCA scientific instruments, including the Electron Microscope, with no down payment, low monthly terms, and a favorable option to buy.

For complete information write to RCA, Dept. P-72, Bldg. 15-1, Camden, N.J.

Crystalloflex IV and Electronic Circuit Panel with Diffractometer and Guinier Camera mounted on the generator.

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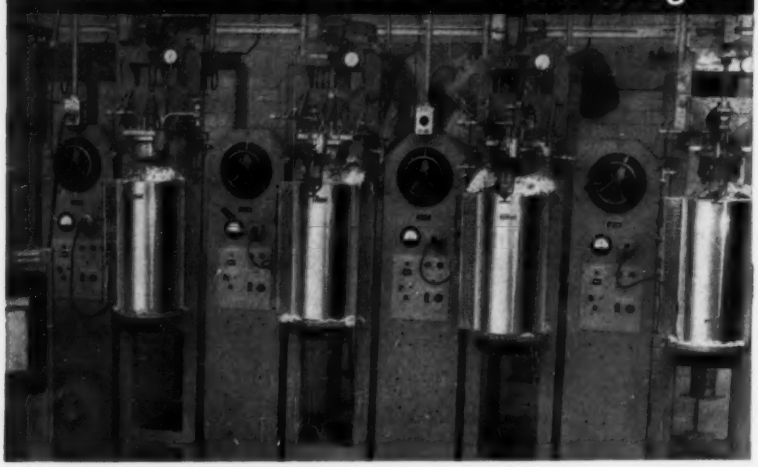
The Most Trusted Name in Electronics

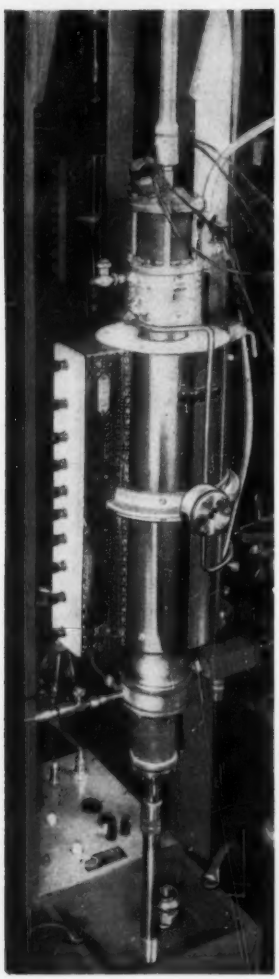
RADIO CORPORATION OF AMERICA

Circle 454 on Page 48-8

Marshall Furnaces at Oak Ridge



1000 to 1800° F ± 1.5°



At Oak Ridge, Marshall furnaces accurately maintain set temperature levels in the range of 1000 to 1800° F., within ± 1.5° F. The furnaces are vital components of specially designed and built gaseous and vacuum creep rigs. Creep properties of structural metals are tested under the effect of high temperature gases, vacuum, various liquids, and liquid metals. The rigs were developed by the Oak Ridge National Laboratory, operated by Union Carbide Corporation for the U. S. Atomic Energy Commission, and the furnaces were built to their specifications by Marshall Products Co. After more than four years of virtually continuous service, all major components are still in operation!

This accuracy and dependability is typical of Marshall furnaces used widely as components of machines for creep testing metallic alloys, and also for tensile, stress-rupture, and fatigue testing of metals, ceramics and cermets.

Marshall offers a range of standard tubular, shunt-type furnaces compactly designed to apply electrical heat *up to 2600° F*, under exact control. Units feature *uniform temperature distribution* and *rigid zone control to ± 3° F* at any point in the test zone. Under certain conditions operators report temperatures can be held to ± 1° F. Test durations may range from moments to 10,000 or more hours.

MARSHALL PRODUCTS CO.
tubular furnaces and control panels
270 W. LANE AVENUE, COLUMBUS 2, OHIO

write today for complete information

Liquid-metal creep testing frames (shown at top)
Creep testing in various gaseous environments (left)

Circle 455 on Page 48-B

Letters . . .

ing solution. Our original intention was to use normal quenching oils because of the alloys we usually use in machine tools. However, just prior to delivery of this unit, the Commercial Induction Co. had a bad oil fire which occurred during the quenching of an alloy steel. When the hose to the quench ring broke during the quenching cycle, oil sprayed across the semiquenched gear, blazed up and then flamed throughout the room. Within 20 min. the entire plant was ablaze, and soon burned to the ground.

This alerted us to the danger from such oil fires and we began to investigate automatic CO_2 units and other possible fire prevention controls. During the course of the meetings on this subject, it was suggested "Why not develop an emulsion quench which would have the cooling rate of oil and the safety of water". Upon this generalized suggestion, we started to work with a local oil supplier. He formulated emulsions, and various ratios of emulsified cutting oil and water were checked out for cooling rates. It finally became apparent that a ratio of one part cutting oil to ten parts water would give the answer desired.

Several problems developed, but were gradually eliminated. For example, we had to change from A.I.S.I. A 4150 steel to A.I.S.I. A 4145 for gears which were furnace quenched, because all gears cracked at the root of the teeth on induction hardening. Conversely C 1045 (for large parts) had to be changed to C 1050 for parts over 3 in. in diameter to maintain the proper hardness.

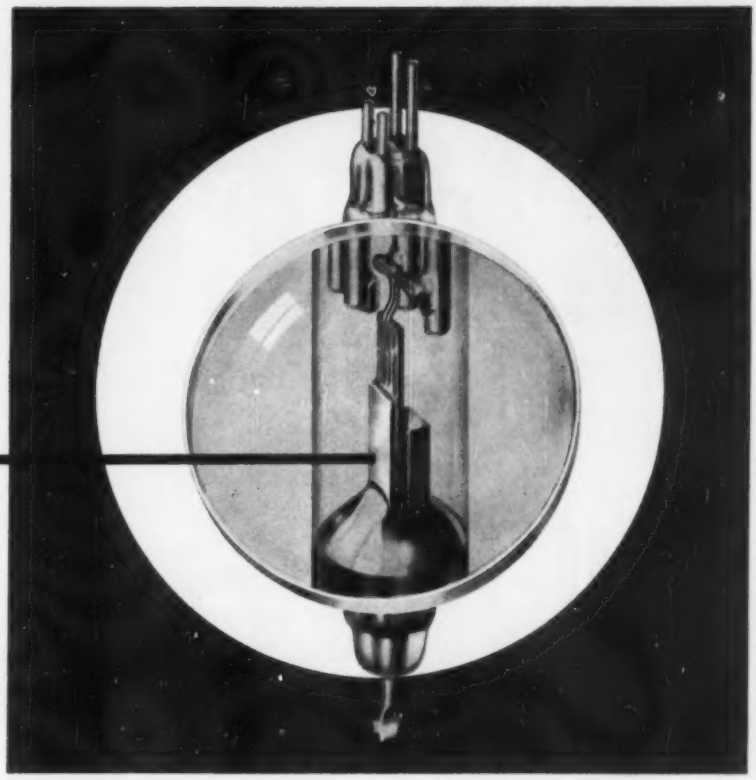
As for the solution itself, the ratio must be kept at 1:10, and checked periodically with a sulphuric acid solution, and the emulsion must be kept under 90° F. for carbon steels and 130° F. for alloys to get uniform hardness.

Most of the information that I have mentioned about the rules and the use of this quench appeared in the Sept. 26, 1957, issue of *Iron Age* under the title "Induction Hardening Small Lots for Extra Benefits". No doubt more people might like to investigate and possibly use this method of quench.

Fire is the worst fear we have,

BILLIONS OF BENDS

Prove SANDVIK SPRING STEEL'S *Fatigue Resistance*



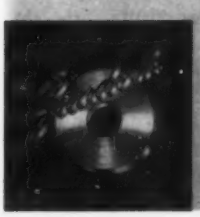
Here is another example of the extraordinary fatigue life you can get from Sandvik Spring Steel.

C. P. CLARE & CO. uses Sandvik 12W12C1 Steel as the spring support for the armature assembly in their line of Mercury-Wetted Contact Relays. Here, from a letter by Mr. C. H. Smith is what they say about it.

"The steel piece deflects through a complete cycle — once for each operation of the relay. Sandvik Steel was chosen for its excellent fatigue resistance. When you realize Clare HG relays have a life expectancy measured in billions of operations you can see the importance we place on selecting top grade materials."

The steel used for this application is only one of Sandvik's many types of specialty spring steels. Each type provides consistent, predictable results for a specific range of application.

For more information on Sandvik Specialty Steels and how they can be applied advantageously, use the coupon below or send us a note on your letterhead.



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1702 Nevins Road, Fairlawn, N. J.
Tel. SWarthmore 7-6200
In N. Y. C. ALgonquin 5-2200

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☐ Please send me further information on Sandvik Steels.
☐ Please have your representative phone for an appointment.

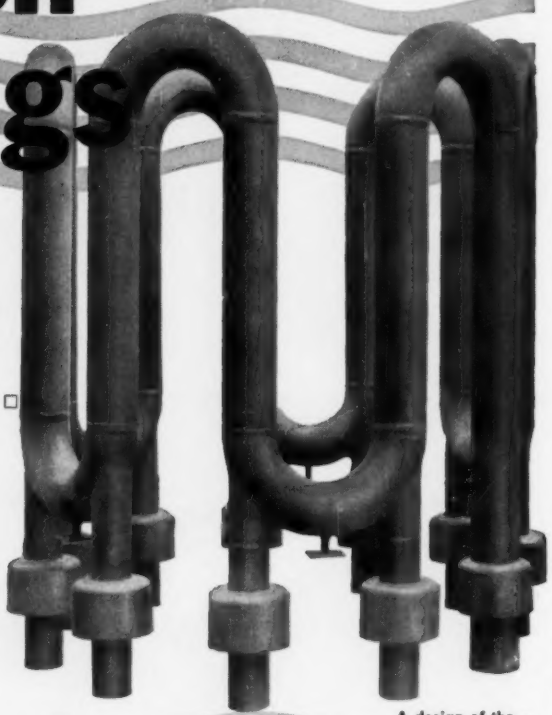
NAME_____ TITLE_____

COMPANY_____

ADDRESS_____

Circle 456 on Page 48-B

when things are HOT... call on Duraloy



A design of the A. F. Holden Co., Detroit, Mich.

Castings that Keep their Load-Carrying Strength at High Temperatures

This "immersion type radiant heater" is typical of the high reliability castings turned out by DURALOY. Centrifugally cast tubes with *UNIFORM* wall thickness...for longest service life. Static cast collars and shell molded bends...typical of DURALOY versatility.

For your high alloy casting requirements check with DURALOY... our long experience, ultra-modern foundry and up-to-the-minute test equipment will be helpful in solving your problems. For more information ask for Bulletin No. 3150 G.

The DURALOY Company
OFFICE AND PLANT: Scottdale, Pa.
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CHICAGO OFFICE: 332 South Michigan Avenue
DETROIT OFFICE: 23906 Woodward Ave., Pleasant Ridge, Mich.

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Letters . . .

particularly when we are doing a lot of heat treating with quenching oils. Fires are not only violent, rapid and costly, but fire departments often do further damage by the improper use of their quenchants (usually water), particularly around salt baths.

ROBERT T. HOOK
Chief Metallurgist
Warner & Swasey Co.

Centenary . . .

(Continued from p. 106)

The first head of this Institute was Fritz Wüst, who was followed by Friedrich Körber, then by Franz Wever and since August 1959, by Prof. Willy Oelsen – all names which resound in the metallurgical world.

But the VDEh also devotes great attention to the promotion of research and education in all fields related to iron metallurgy. Recognizing that this work is urgently needed, but that contributions from the State are not sufficient, the supporting member-plants have appreciably increased their contributions by special assessments ever since 1952. Consequently considerable amounts have been available in recent years for the erection and expansion of technical institutes. After approval by our respective committees, several research projects have been supported by the same funds. A noteworthy condition here is that none of the special funds contributed by the plants for the promotion of research and education can be returned, directly or indirectly, to that plant, but are used exclusively for research outside the direct field of interest of the contributor.

Metallurgical Education

Education of the younger generation has been an important activity of VDEh even in the early days. The predecessor "Technical Society" held long debates on the desirability of laboratories for chemistry and mechanics as an adjunct to the more formal education, and it is not too much to say that it furnished the impetus for building the famous Technischen Hochschule in Aachen. In recent years the educational com-

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A. W. Iron Powder can be your key to new design flexibility, reduced production costs and products of superior quality with closer tolerances. A.W. Iron Powder assures you of high purity, uniformity of size and composition . . . plus outstanding fabrication properties. Custom-mixed blends are readily produced to meet your most exacting specifications.

You're assured of prompt deliveries with A.W. Iron Powder, now being manufactured in volume in our 50-ton-a-day direct reduction plant. Behind these modern facilities are years of pilot plant operation, thorough testing and proving in customer applications.

And you're assured, too, of continuing quality and competent service. A.W. Iron Powder is backed by the full resources of Alan Wood Steel Company . . . extensive laboratory and research facilities . . . application engineering . . . and Customer Advisory Service to help make your investment more productive. Send today for technical data and application information . . . fill in the coupon below for samples and details.

ALAN WOOD STEEL COMPANY
CONSHOHOCKEN, PA.

FOR MORE INFORMATION

Manager
Iron Powder Sales
Alan Wood Steel Company
Conshohocken, Pa.

I am interested in Iron Powder for:
☐ Molding ☐ Friction ☐ Other
☐ Send literature ☐ Send sample

NAME_____
TITLE_____
COMPANY_____
ADDRESS_____ CITY_____ STATE_____

AMERICAN STEELMASTERS FOR 135 YEARS

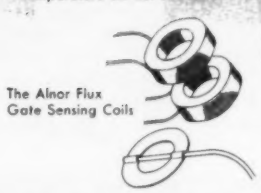
Not a worry in the world

...with *Alnor* PYROTROLLER®

positive temperature control

1. Pyrotroller—an electronic temperature controlling instrument.
2. Pyrotac—a safety excess temperature cut-out or alarm.

Dependable automatic control of temperatures in heat treating furnaces, ovens, plastic moulding, cooking vessels or for any constant temperature requirement. Operates to prevent overheating even with power failure.



The Alnor Flux Gate Sensing Coils

The simple, rugged circuitry in the Pyrotroller has a minimum of components that operate well below their rated capacities. The circuit is not critically tuned and there is no need for repeated adjustment, no shifting of the control point, no need for preselection of the one standard vacuum tube. Sapphire jewel bearings and the very high Alnor standard of precision construction makes the Pyrotroller extremely accurate particularly in the low temperature ranges.

The Alnor Pyrotroller is available in a wide range of temperatures, —100° F. through various maximum temperatures up to 3000° F. The minimum scale span is 400° F. and various ranges can be supplied to meet your particular installation. Write for complete information. Our engineering service is available on special requirements.

Alnor INSTRUMENTS

ALNOR INSTRUMENT CO.

Division of **Illinois Testing Laboratories, Inc.**

Room 523, 420 N. LaSalle St., Chicago 10, Illinois

Circle 459 on Page 48-B

Centenary . . .

mittee of VDEh has been constantly in touch with all important institutions teaching metallurgy and is ready to advise as to curricula and educational plans.

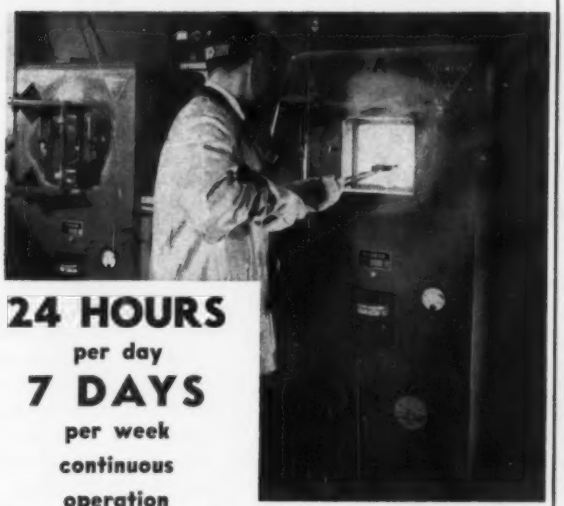
Furthermore the young graduates are assisted in finding suitable occupations. Our general attitude is that the years in school are so filled with fundamental scientific and cultural studies that the graduate will possess little information about the intricacies of practice. To him such things as power economy, costs, plant operations and labor relations are a closed book. To close this gap the VDEh is promoting the establishment of positions known as plant assistants, where for 18 months the young metallurgists will serve (at regular pay) as junior workers in the accounting, testing, inspection, standardization, fuel or heat-economy and other departments. At the end of that time they are in a much better position to choose the field in which they wish to specialize.

Literary Activities

The chief literary activity of the Society is the magazine *Stahl und Eisen*. Now in its 80th year, it is the indispensable bond keeping all the members together. It publishes the complete proceedings of the technical meetings and, in its "Umschau", comprehensive extracts and surveys of literature on all advances in iron and steel metallurgy. Statistical reports are presented in the section known as the "Economic Review", and cover production and economics of the iron and steel industry at home and abroad. This section has been formulated for long decades in cooperation with the Wirtschaftsvereinigung Eisen und Stahlindustrie (Iron and Steel Federation) or its predecessors. Current literature is annotated and reviewed in the section entitled "Periodical and Book Review", listing all noteworthy articles in more than 600 technical journals of the world. Exhaustive semi-annual indexes are provided so that every volume of *Stahl und Eisen* will remain a reference work for decades.

At first the proceedings of our professional committees were published as separate pamphlets, especially when they concerned a field of basic

PERECO Electric KILNS



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—And at temperatures from 2250 degrees to 2700 degrees F. That's the service these Pereco Kilns are rendering Corning Glass Works. And it is not unusual! It is typical of the efficient day-in and day-out dependable service that has made Pereco "first choice" with hundreds of the nation's leading firms. Let us consult with you on your Kiln or Furnace needs.

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Circle 460 on Page 48-B

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Seven Revco cabinets, both chest and upright styles, are available. Capacities range from 1.5 to 6 cu. ft. in chests and to 22 cu. ft. in uprights. Units provide temperatures to —140° F. controllable within ±1°. Optional accessories are offered. Immediate delivery on all units.

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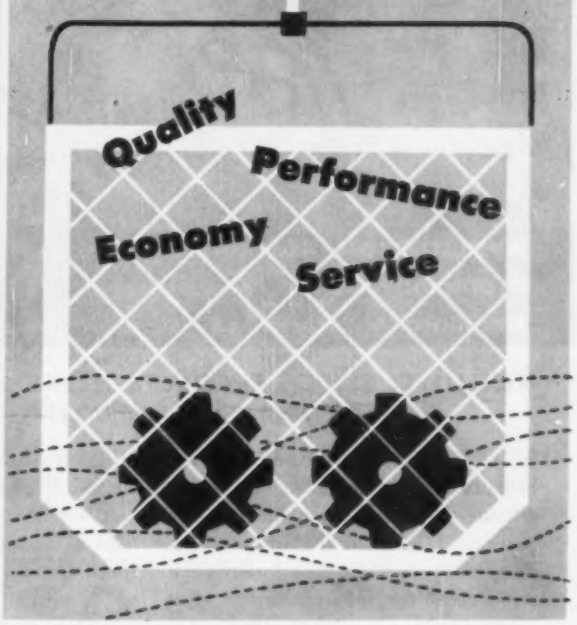
Circle 461 on Page 48-B

HEATBATH SALT BATHS FOR



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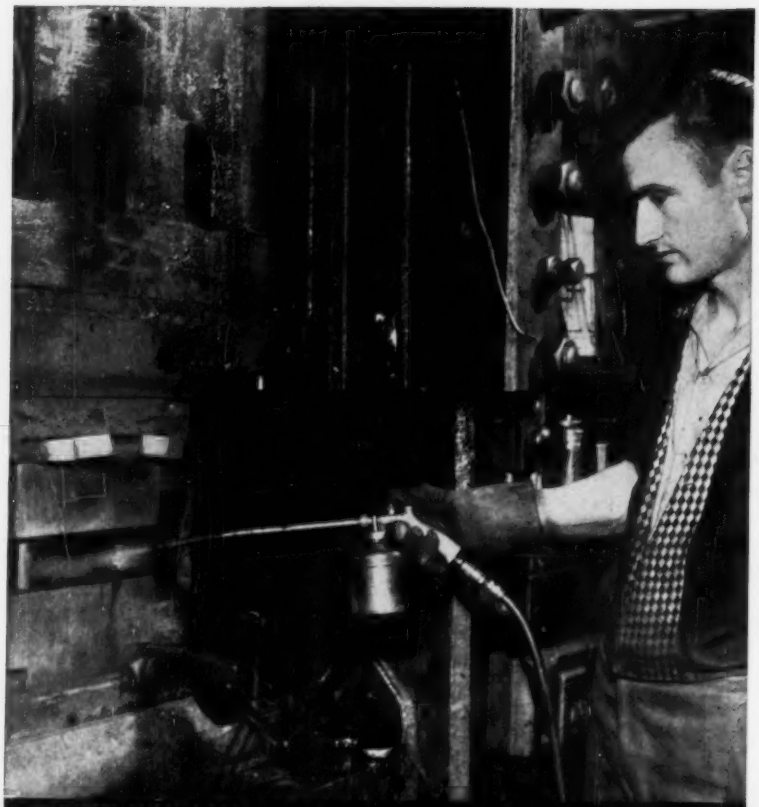
Circle 462 on Page 48-B

FORGING REPORT



APPLICATION: *Aluminum Alloy Forgings.*
Problem: *Find a better die lubricant.*
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RESULT: *SCHICK PRODUCTS SAVES 20% IN FORGING OPERATIONS*

Schick Products, Inc., Belmont, California, gained three important benefits by spraying 'dag' 3 on their pre-heated dies before forging aircraft and missile components. They found that this Acheson dispersion: 1. reduced the amount of lubricant necessary, because of its greater coverage, 2. allowed greater speed and efficiency in the removal of forgings from their dies, and 3. virtually eliminated former sticking conditions between forging and die, providing longer die life and fewer rejects. By their own estimate, these operating savings have amounted to at least 20%!

If you are interested in lubrication efficiency, write for further information. Send for Bulletin No. 426. Address Dept. MP1.

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PORT HURON, MICHIGAN

A division of Acheson Industries, Inc.
Also Acheson Industries (Europe) Ltd. and affiliates, London, England.
Sales offices in principal cities.

Circle 463 on Page 48-B

Centenary . . .

research or were addressed to only a small group of experts. To insure a wider distribution a supplementary periodical was established in 1927 entitled *Archiv für das Eisenhüttenwesen* (Metallurgical Archives). It has subsequently included all the more scientific documents and research contributions, and rapidly grew into a publication which we could not think of doing without.

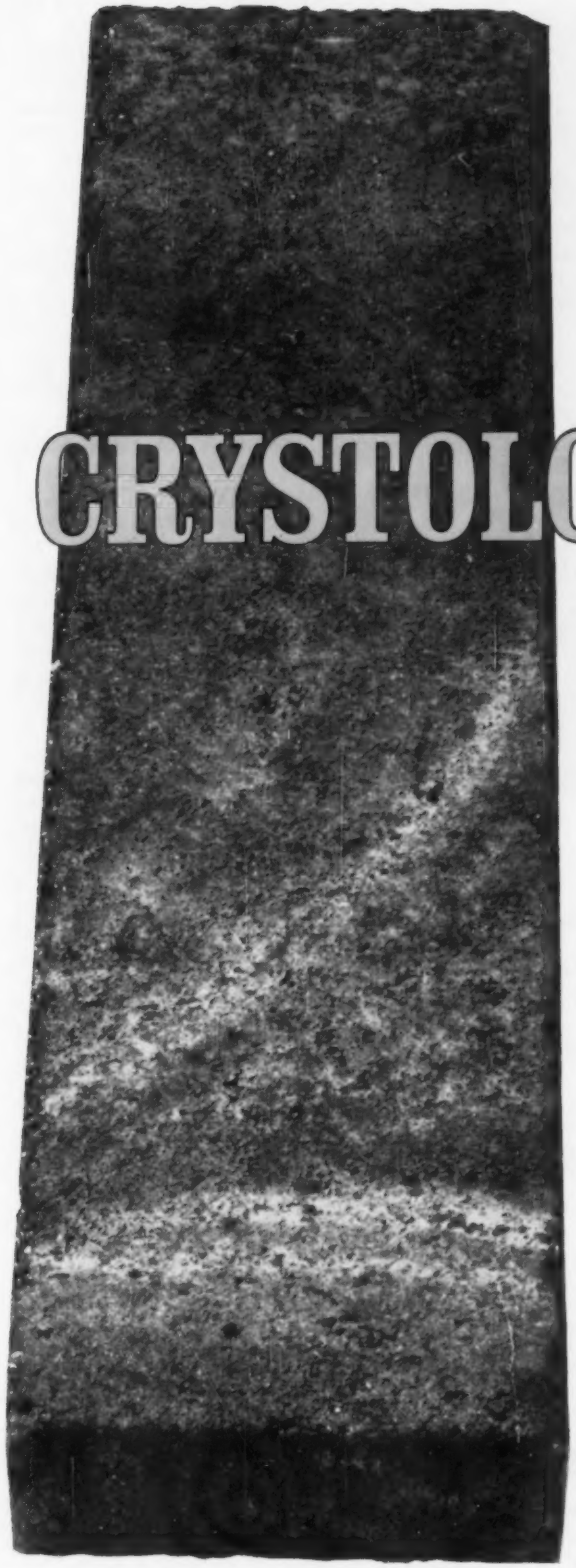
It will be seen that the publication policies of VDEh and the A.S.M. are roughly parallel, except that the American society makes no attempt to gather and print industry statistics. Figure 2 (p. 104) shows the number of reading pages printed annually by *Stahl und Eisen* since its foundation in 1881 and by *Archiv* since 1927. The press run on *Stahl und Eisen* is currently about 12,000 copies, of which a third go to 55 countries outside of Germany – certainly an index of its importance.

Standardization

An important aspect of cooperation between VDEh and the consumers of metal in Germany has been its activities in the field of standardization and, as a byproduct, the constant improvement in uniformity and quality. General standardization is authorized by a State Committee, but under that direction VDEh manages the Professional Committee on Standards for Iron and Steel, formed in 1947. This parallels the work of the American Iron and Steel Institute in formulating and revising standards of quality, sizes, delivery and the like. The Professional Committee also cooperates wholeheartedly in solving standardization problems studied by the European Coal and Steel Community and the I.S.O. (International Standards Organization).

Library

The library of the Verein Deutscher Eisenhüttenleute was founded in 1905. Its resources and those of the information bureaus connected with it are available not only to the members, but to the general public in the spacious reading room. The library now contains about 83,000 volumes. Access is provided by an author and subject catalog with far more than a million cards. There is



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Now, the best-performing silicon carbide refractory is available at a realistic price! Brand-new CRYSTOLON "63" permits the use of a cost-saving nitride-bonded silicon carbide refractory for hundreds of applications.

Produced by an exclusive Norton process, CRYSTOLON "63" silicon carbide provides all the superior properties of nitride-bonded silicon carbide at a *new low cost!* It has high thermal conductivity, excellent heat shock and wear resistance, and good resistance to most corrosive liquids. In extensive tests, it not only showed excellent resistance to "wetting" by molten non-ferrous metals (aluminum, magnesium, zinc, lead and others) but also to fused salts, such as cryolite!

CRYSTOLON "63" refractories can well mean a vast improvement in many of today's metal melting and transfer operations . . . new efficiency and economy *throughout* operations such as *yours*. Get complete details now! Write NORTON COMPANY, Refractories Division, 320 New Bond Street, Worcester 6, Massachusetts.

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• Wilson Rockwell Superficial hardness testers are used to measure surface hardness, coatings, thin metal or thin hard cases. The hardness test is based on a penetration of less than .005", and Wilson Superficial testers have the precision and ease of operation to give accurate readings every time.

Accurate—Precision-built for consistently correct results. Knife-edge bearings provide near-frictionless operation.

Easy to operate—Controls conveniently grouped—oil dash-pot system provides smooth load application.

Long lasting—Simple design, rugged construction make Wilson Superficial testers as durable as a machine tool.

Complete line available—Wilson Rockwell hardness testers and accessories are available in a wide variety for every hardness testing function.

Wilson "Brale" Diamond Penetrators Each diamond is cut to an exact shape. A comparator check and microscopic inspection of each diamond assure perfect readings every time.

Write for details—Ask for Catalog RT-58. It gives complete information on the Superficial tester as well as on the full line of Wilson Rockwell hardness testers.

WILSON "ROCKWELL" HARDNESS TESTERS

ACCO

Wilson Mechanical Instrument Division
American Chain & Cable Company, Inc.
230-F Park Avenue, New York 17, New York

Circle 465 on Page 48-B

Centenary . . .

also a collection of all the German patents, whose number now is likewise more than a million, a photograph collection with about 2500 pictures relating to the history of iron. Finally we have recently acquired a collection of translations, which should help especially in following the literature of the countries to the East.

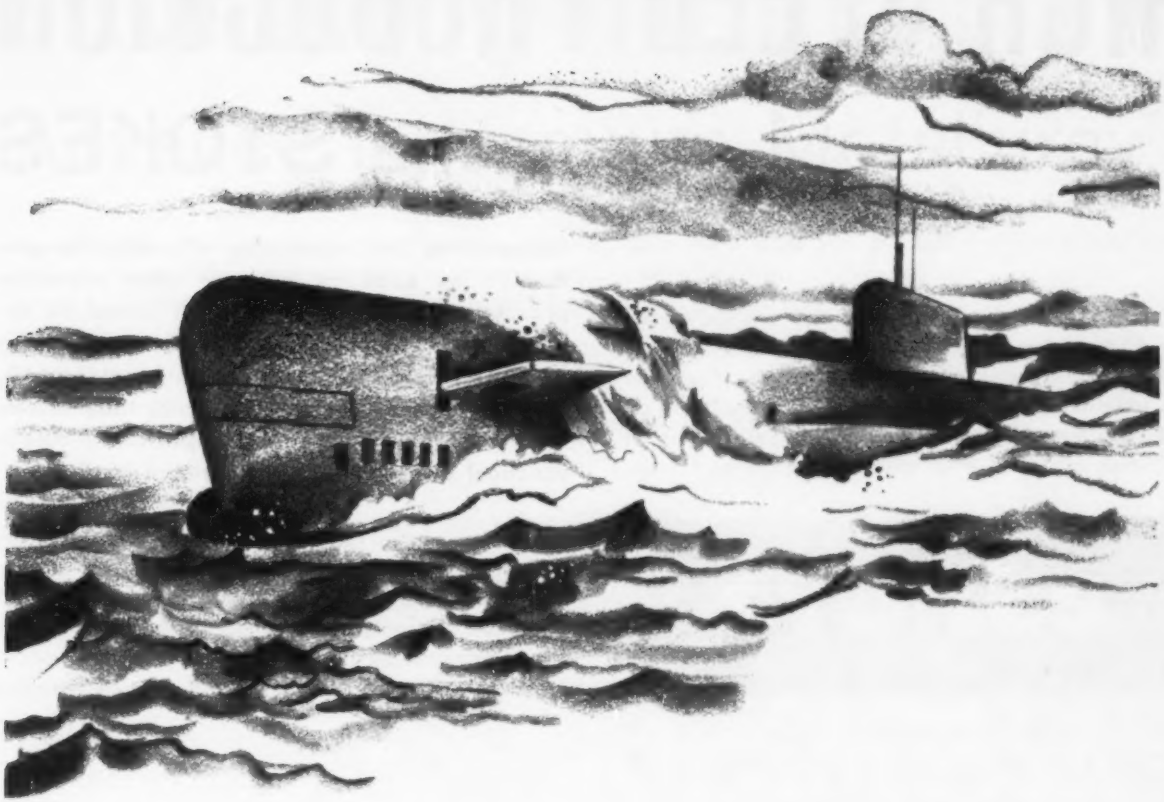
International Relations

The cultivation of relations with foreign groups dates back to the beginning of the organization. In August 1880, even before the change of the Society to its present form of organization, the Iron and Steel Institute of Great Britain held a joint meeting in Düsseldorf with the Technische Verein für Eisenhüttenwesen. Other meetings of a similar nature, held in the early years, were with the Société des Ingénieurs Civils in Paris, the Société de l'Industrie Minérale in St. Etienne, and the Comité des Forges de France.

The earliest contact with a group of American experts occurred in July 1889, when 50 members of the American Institute of Mining Engineers, invited by the Rheinisch-Westfälischen industries, visited a number of industrial plants under the guidance of their professional associates. This resulted, among other things, in an invitation to participate in the autumn meeting of the A.I.M.E. Since the Iron and Steel Institute of Great Britain also sent representatives to the meeting, we can say that the first international metallurgical meeting took place in 1890.

Space does not permit listing the many meetings with foreign associations, either at home or abroad, which have occurred at frequent intervals since then. Through the years many of our noteworthy members have been made honorary members of these sister societies. We should mention, however, the pleasant and profitable meeting of the metallurgical societies in Europe in the summer of 1955, participated in by the American Society for Metals, the American Institute of Mining and Metallurgical Engineers, the Iron and Steel Institutes both of America and Great Britain, the Verein Deutscher Eisenhüttenleute and

when you're producing Electric Steels



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Circle 466 on Page 48-B

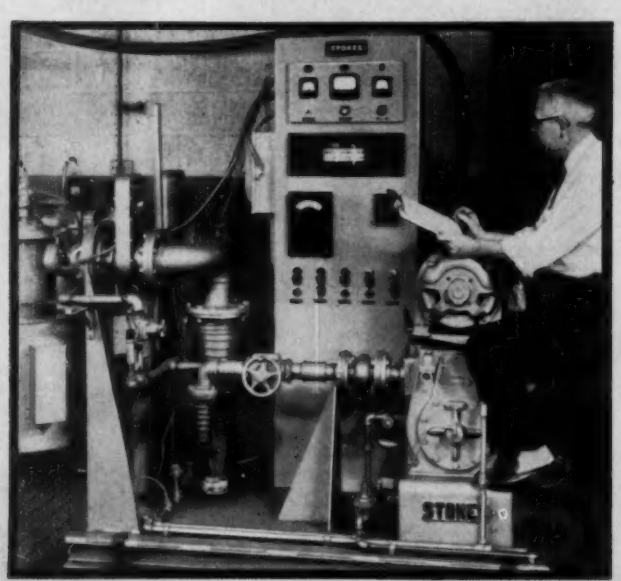
HIGH SPEED PRODUCTION

...a STOKES

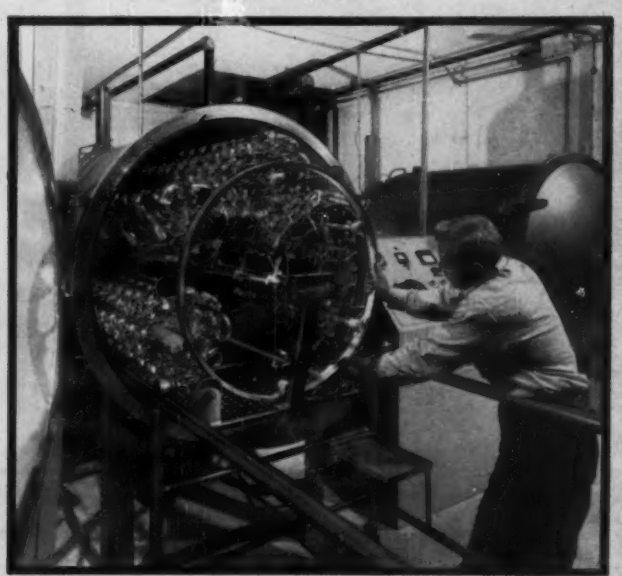
Recognizing the importance of profitable production as soon as possible after prototype proving, Stokes has made high speed an inherent factor in its vacuum metallurgical equipment. With each technological breakthrough, Stokes vacuum engineers intensify their efforts to convert the research accomplishment into a practical and profitable production reality.

From research and development to system installation and operation, Stokes unmatched technical competence and unparalleled experience assure you the most advanced performance in vacuum metallurgy. Stokes led in compressing the time from prototype development to full scale production. Now, Stokes offers

At Associated Spring Corp., Bristol, Connecticut, precision springs finer than a human hair are vacuum heat treated to rigid specifications. Fabricated from critical alloys, they require precise processing. A Stokes Vacuum Furnace enables production of springs for even the most delicate instruments.



Welsh Industries uses two Stokes vacuum metallizers in first and second surface metallizing of a variety of automotive and appliance parts. Because they require less attention, one operator can supervise two Stokes metallizers. Welsh has realized a 20% production increase since installing the Stokes units. The compact size of the Stokes metallizers saves Welsh 10% in floor space.



COUPLED WITH QUALITY

Advance in Vacuum Metallurgy

realistic high speed, profitable production . . . stemming from complete vacuum system engineering. A recently installed Stokes high production furnace has produced over 1,000 heats in just 3 months!

Stokes offers the most complete range of types and sizes of vacuum furnaces and metallizers . . . as well as custom-designed systems. For example, we have demonstrated our capability in supplying a complete turnkey installation—erected, tested and delivered in operation. Result: you profit from a single source of responsibility.

If you have out-of-the-ordinary requirements, we can handle them also. The large majority of special installations throughout the United States are Stokes-engineered. And whether it's a special system or production unit, you get faster delivery and fewer costly holdups.

Let us put our vast experience and complete facilities to work for you. Stokes Engineering Advisory Service will work closely with you in planning and designing an installation that will serve both your present and future needs . . . profitably. May we invite you to contact us directly in order to learn all the facts?

STOKES

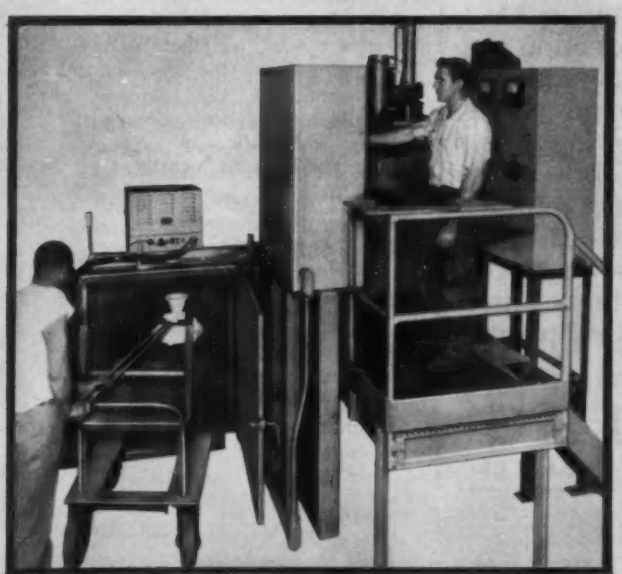
Vacuum Metallurgical Division

F. J. STOKES CORPORATION

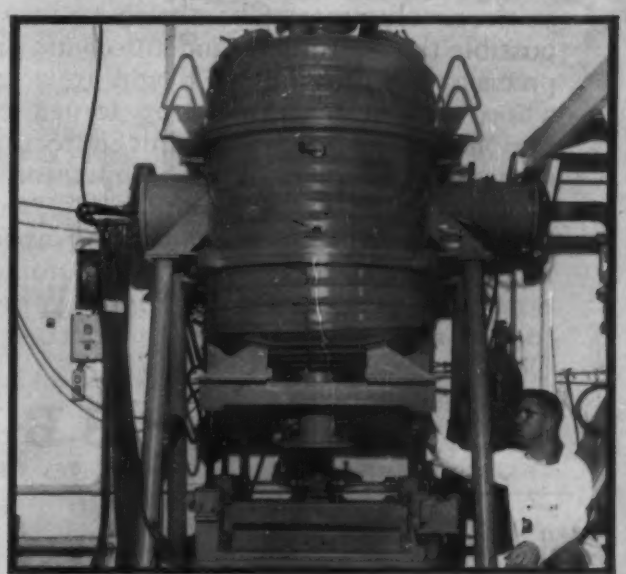
5500 Tabor Road, Philadelphia 20, Pa.

Circle 467 on Page 48-B

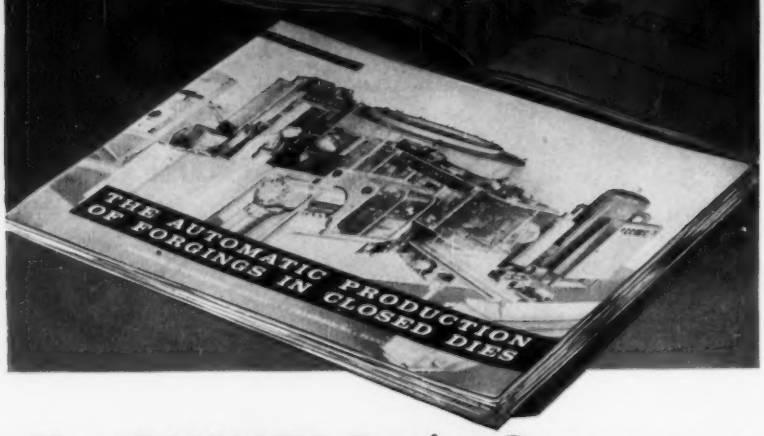
At Misco Precision Casting Co., semi-continuous vacuum melting and casting is being accomplished in two versatile Stokes induction furnaces. Successive charges of the metal can be introduced into the vacuum chamber from the outside, loaded into the crucible, melted, poured, and the cast pieces (in their molds) removed from the chamber . . . all without breaking the vacuum.



Installed at Atomics International, this Stokes 50 KW vacuum furnace is casting long, hollow uranium cylinders to such size tolerances that no subsequent machining is required. For another project, the furnace operates remotely in casting uranium fuel slugs. In both instances, maximum precision must be sustained through tight, large-scale production schedules.



do your plans include mechanized drop forging?



The CECOMATIC Forging Process, based on the revolutionary Chambersburg Impacter, makes possible the continuous and automatic production of precision drop forgings. If you are a manufacturer whose products include drop forged components, you must consider mechanized forging in your plans for the future...your competition will do so—sooner or later. Practical information, with examples of successful mechanized forging operations, are included in the brochure, "The Automatic Production of Forgings in Closed Dies". Write for a copy today, to Chambersburg Engineering Company, Chambersburg, Pennsylvania.

CHAMBERSBURG

DESIGNERS AND MANUFACTURERS OF THE IMPACTER

Circle 468 on Page 48-S

Centenary . . .

Deutsche Gesellschaft für Metallkunde of Germany, the Centre National de Recherches Metallurgiques (Belgium), the Société Française de Metallurgie (France), the Jernkontoret (Sweden), and other cooperating societies. It was an especial pleasure to us on this occasion to nominate Wm. H. Eisenman, late secretary, and George A. Roberts, then president of A.S.M.; Ernest O. Kirkendall, secretary of A.I.M.E.; and Howard Biers of the International Institute of Welding as foreign honorary members of VDEh, and to accept the same honors for the president of our Society, Prof. Dr. Hermann Schenck and our manager Dr. Ing. Kurt Thomas.

Finally we must not forget to mention a notable expansion and permanent promotion of international relations which has been achieved in recent years through the exchange of young engineers. So far about 430 young German metallurgists have been able to expand their horizons by their own observations and by practical cooperation, especially in English, French and Austrian plants. During this time a like number of foreign exchange partners have spent time in German mills. The Verein Deutscher Eisenhüttenleute regards this as an especially suitable means of broadening international relations and thus promoting the aims for which we have been striving since a century ago.

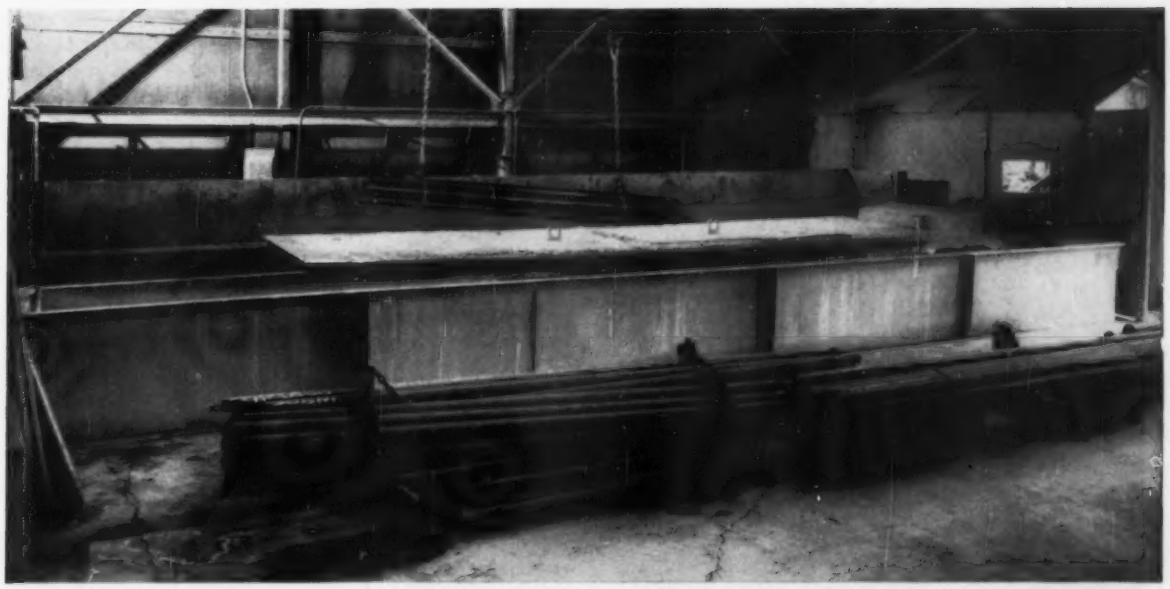
Metallurgical Progress...

(Continued from p. 120)

traverses a solid, and these energy losses depend on the mechanical characteristics of the material—especially the applied stress. Attenuation measurements show that static stresses far below the macroscopic yield stress may move the dislocation loops without generating new dislocations.

After a little, recovery occurs and the ultrasonic attenuation decays to its original value. This effect, not previously observed in iron-carbon alloys, would indicate the breakaway of dislocations, and may suggest means to improve fatigue characteristics of alloys used in engineering practice. Impurities, cold

THE TIMKEN COMPANY CUTS DESCALING TIME



FROM 90 MINUTES TO 30 MINUTES

How Virgo® Descaling Salt gives faster, safer cleaning.

It used to take as much as ninety minutes of straight acid pickling to descale these stainless steel tubes at the Gambrinus Works of The Timken Roller Bearing Company.

Since switching to Virgo Descaling Salt, The Timken Company reports that descaling cycles have been cut down to *one-half* hour with actual acid pickling time reduced to 10 minutes. Equally important too, is the improvement in surface quality.

In the same bath, which handles bundles up to 37 feet in length, the tubes are degreased.

Get these other Virgo advantages in your descaling:

Besides stainless and alloy steels, Virgo Descaling Salt descales titanium and its alloys. You can even handle both types of metal in the same bath.

Virgo Salt reacts only with scale. There's no loss of base metal, no pitting or etching. There's no danger of hydrogen embrittlement.

The Virgo bath is safe and simple to operate, using normal precautions. Bath temperatures run from 800 to 1250°F.

You can descale strip, sheet, bars, wire, tubes, castings, or any other form to a chemically clean surface.

You use much less acid with the Virgo process.

For more information on how Virgo Descaling Salt works, write for Bulletins 25 and 25-T (Titanium).

Help for your other metal cleaning operations.

Descaling. Use Virgo Electrolytic Salt to remove sand, graphite, other impurities—produce a chemically clean surface.

Reclaiming parts loaded with carbon or rust. Virgo Molten Cleaner works fast—is the quick answer for large-scale salvage operations.

Vapor degreasing. You get unique stability—degrease more parts between cleanouts—using Nialk® *Trichlor*ethylene with *psp* (permanent staying power).

Stripping, acid neutralizing. You can get Hooker caustic soda in four convenient flake sizes, in new easy-to-empty drums with 18" openings.

Acid cleaning, pickling. You can get Hooker muriatic acid in 4,000-, 6,000- or 8,000-gallon tank cars.

Plating with tin-zinc, tin, silver, copper. Get the benefit of more than 50 years' experience in potash production, when you specify Nialk® caustic potash for your plating operations.

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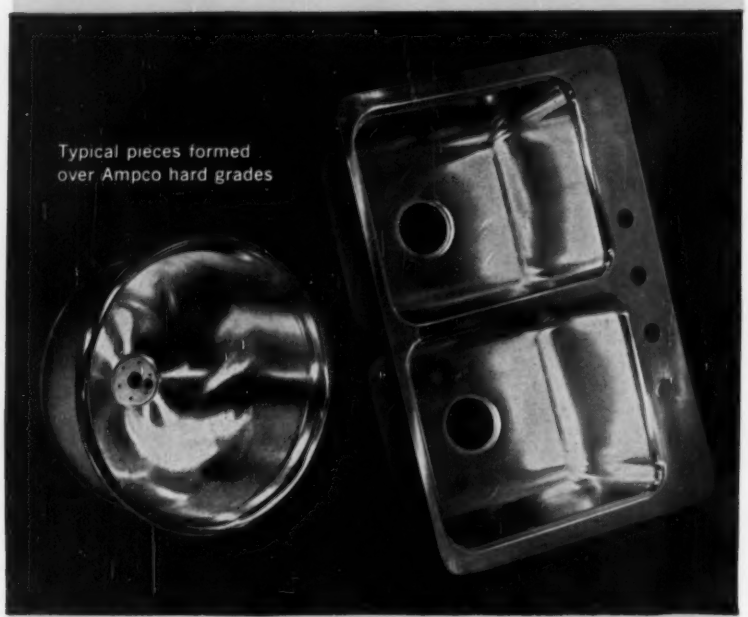
AMPCO®

Ampco® announces a

NEW, IMPROVED ALLOY

for drawing and forming stainless steel



DiBronze

(PATENT PENDING)

Longer life between dressings. Improved machining qualities. Better impact resistance.

Now in stock — cast rectangles, solid rounds, centrifugally cast die blanks up to 20" diam.

Also cast to your required shape.

Write for bulletin today.

AMPCO metal

AMPCO METAL, INC.
Dept. 24A,
Milwaukee 1, Wisconsin
West Coast Division:
Huntington Park, Calif.
Southwest Division:
Garland (Dallas County), Texas

Circle 470 on Page 48-E

Metallurgical Progress...

working of the surface, and fine-grained structure may introduce short loop lengths less liable to suffer from the effect of applied stresses. A further application may be early detection of fatigue.

Solid-State Physics

Space limitations permit only cursory mention of a considerable number of investigations in the field of metal science prosecuted principally in those Canadian universities having metallurgical curricula. For example, Prof. F. A. Hames at Queen's University is studying magnetic alloys.

Atomic Architecture

A very active research division at McMaster University at Hamilton, Ont., is under the direction of H. E. Petch. (This university has the 1,000,000-watt nuclear reactor illustrated on p. 118.) His special interest is crystallography. X-ray determinations of the atomic architecture of metal borates, hydroxides and silicates are supplemented with nuclear studies (magnetic spin resonance). Recently, neutron diffraction techniques have been introduced for determining the atomic positions of light elements in alloys of the heavy metals.

Whisker Metallurgy

Copper "whiskers" are being intensively studied by E. Teghtsoonian at the University of British Columbia. Tensile testing while the sample is immersed in acid solutions proves that the remarkable strength does not derive from an oxide layer. With minor exceptions, the load-elongation curve has a region of elastic deformation, then a sudden yield occurs with a drop in load, next occurs plastic flow at the flow stress with virtually no work hardening, and finally a period when extension up to fracture is accompanied by work hardening. Apparently there is no simple relation between the distribution of dislocations and the strength of a whisker, as has been proposed in earlier speculations.

Some work on binary alloys of titanium at the University of Alberta seeks to elucidate doubtful portions of some of its constitutional diagrams, clarify the nature of quenched

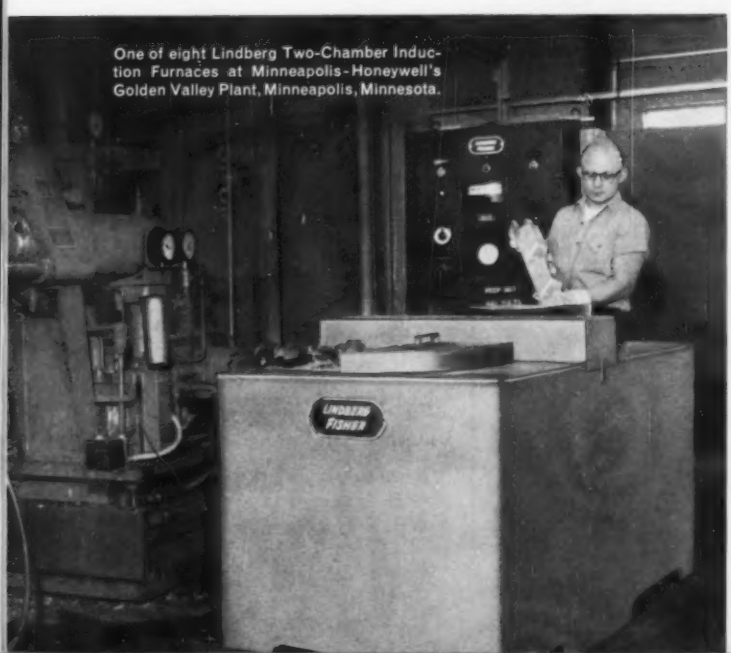
ART GEORGE has a good word to say for Lindberg Melting Furnace performance

QUOTE

Mr. Art George, Senior Production Engineer, Golden Valley Plant, Minneapolis-Honeywell Regulator Company, Minneapolis, Minn.

"Our installation of eight* Lindberg-Fisher Two-Chamber Induction Melting and Holding Furnaces has given remarkable service for more than four years. In this period, with the help of a well executed Honeywell maintenance program, the installation has been unusually trouble-free. Only one of the eight furnaces has required relining over this long period. Handling more than 1,000,000 pounds of aluminum and zinc annually, the installation has unfailingly provided the consistently high quality of metal our precision instruments require."

**Altogether, 44 Lindberg Furnaces are in operation in various Honeywell plants.*



One of eight Lindberg Two-Chamber Induction Furnaces at Minneapolis-Honeywell's Golden Valley Plant, Minneapolis, Minnesota.

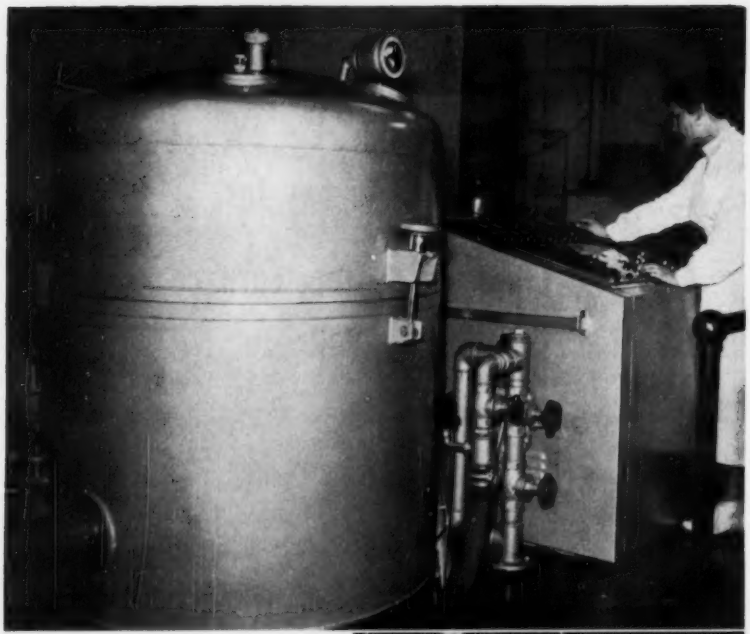
These eight Lindberg-Fisher Induction Furnaces melt and hold aluminum and zinc for die casting gas valve housings and other component parts. They are located at the die casting machines where ingot and scrap can be melted and held at the desired casting temperature in one convenient unit. Magnetic fluxing and stirring insures uniform temperatures and consistently clean metal.

In any production process where aluminum needs heat there is Lindberg equipment to apply it most economically and efficiently. Furnaces for melting and holding, casting stations, re-melting or heat treating are available in all capacities, electric or fuel fired. Get in touch with your Lindberg Field Engineer (see your classified phone book) or write us direct. Lindberg-Fisher Division, Lindberg Engineering Company, 2448 West Hubbard St., Chicago 12, Illinois.

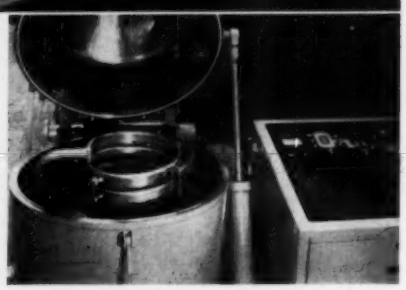
Los Angeles plant: 11937 S. Regentview Avenue, Downey, California. In Canada: Birlefco-Lindberg Ltd., 15 Pelham Ave., Toronto 9, Ont. Also, Lindberg plants in Argentina, Australia, England, France, Italy, Japan, South Africa, Spain, Switzerland and West Germany.

Circle 471 on Page 48-B

LINDBERG
heat for industry



Sinter in Vacuum up to 3,000° C!



Water-cooled, wear-free induction coils produce electro-magnetic field for fast, uniform heating.

Centigrade, notice, not Fahrenheit. This temperature has many times been achieved, and maintained, under laboratory conditions with Heraeus Induction Sintering Furnaces. In production, temperature range of 2,600°C to 3,000°C is typical.

More significant, these Heraeus furnaces improve end product quality while cutting operating costs. You get uniform heat distribution . . . faster heating . . . and longer element life . . . than with any other vacuum furnace on the market today.

There's a complete line to meet your needs, with coil diameters from 6¾" to 20½" . . . with choice of pumping systems for working pressures from atmosphere down to the 10^{-5} range. Each gives you complete facilities for the widest range of vacuum metallurgy: sintering, reactive work, degassing, purification of metal powders, brazing, annealing, hardening. Each saves the high cost of constantly replacing the expensive elements required in resistance heating.

Find out more about higher quality work, lower operating costs. Write for Bulletin 4-25.

Consolidated Vacuum Corporation

ROCHESTER 3, NEW YORK

Circle 472 on Page 48-B

Metallurgical Progress . . .

microstructures and their isothermal decomposition, and to relate metallographic structures with mechanical properties.

Dislocations in thinned metal foils have been studied at Mines Branch in Ottawa with a transmission electron microscope. This technique is also being used to examine the early stages of the precipitation of carbon in iron; the positions and shape of the initial precipitates which form and their relationship to the dislocations in the material can be directly observed.

Effect of Intense Irradiation

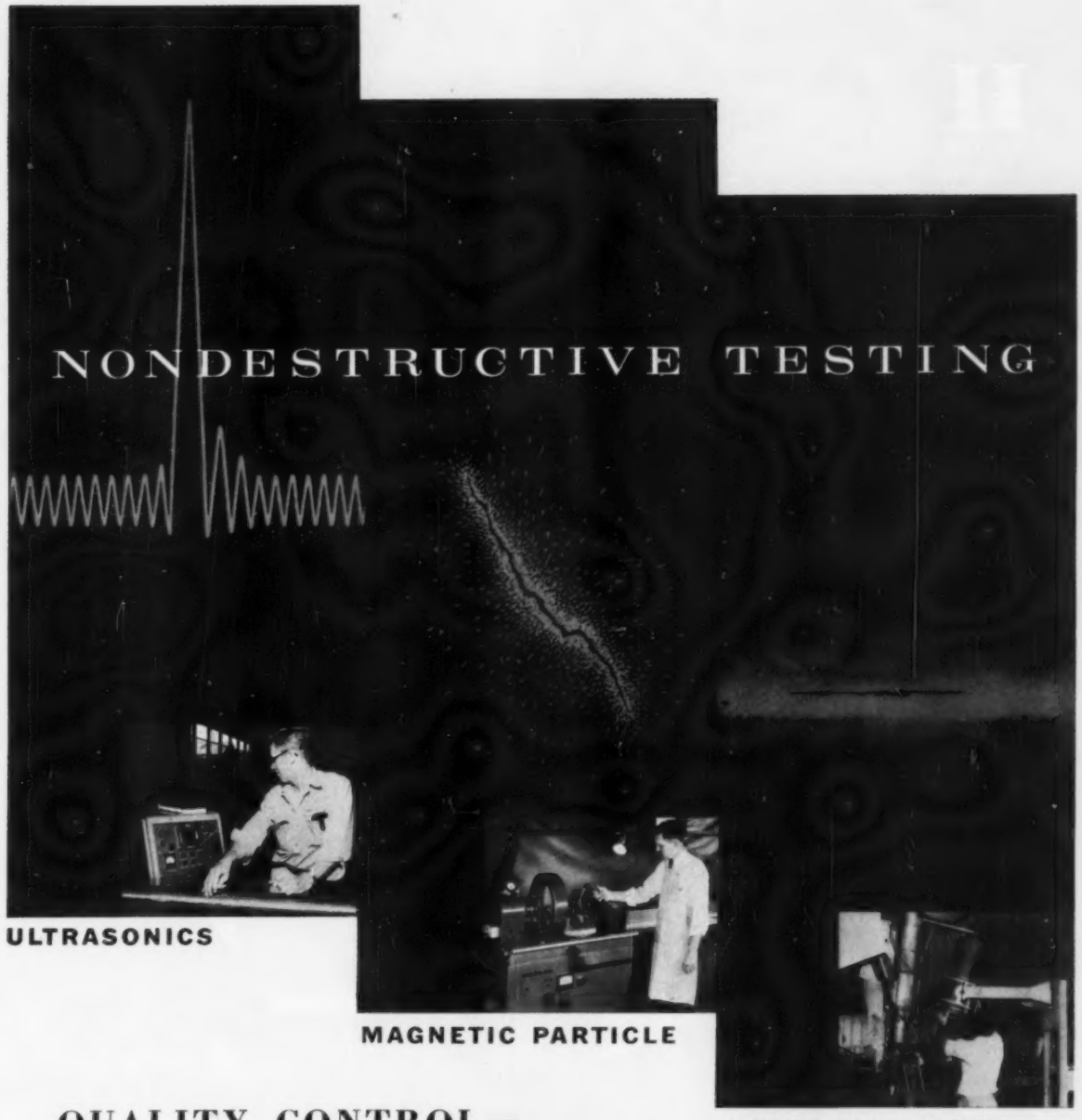
This cursory account of a large number of metallurgical investigations cannot close without devoting some space to the intensive work done since 1955 by the research metallurgy branch at the Chalk River Project of Atomic Energy of Canada Ltd. on the effect of neutron bombardment on the physical and mechanical properties of metals and alloys.

Many alloys have been studied, including Al-Mg alloys of several commercial compositions, 65 S, M 257 (Al with 7% Al_2O_3), magnesium alloys, Inconel, mild steel and Zircaloy-2. Irradiation at 50 to 100° C. (122 and 212° F.) has small effect on the mechanical properties of the Al and Mg alloys. The Al-Mg alloys are of great interest, for it was found that the increase in yield strength for a given radiation dosage was dependent on the magnesium content, the maximum effect occurring at about 0.5% Mg and decreasing to zero at about 2.5% Mg.

Irradiation of mild steels shows several interesting effects. First, the initial advantage of low brittle-ductile transition temperature in normalized iron containing 3.25% nickel was soon lost. Increasing the nickel to about 9% (A 353 steel) minimized this effect; even after heavy irradiation the transition temperature for miniature samples was below room temperature. It is thought that a small amount of retained austenite is partly responsible.

Diffusion Rates

Because neutron bombardment creates vacancies in a metal lattice, it has always been supposed that



QUALITY CONTROL— the Key to New Profits

In today's highly competitive market more and more manufacturers are turning to nondestructive testing as a sure means of improving their profit picture.

One manufacturer credits Sperry Ultrasonic test equipment with being directly responsible for increasing volume a full 20%. And it has enabled him to efficiently compete for orders in fields demanding the utmost in quality and reliability.

To get the most profitable results from nondestructive testing, call on Sperry Products Engineers for proper evaluation of your quality control problem.

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Circle 473 on Page 48-8

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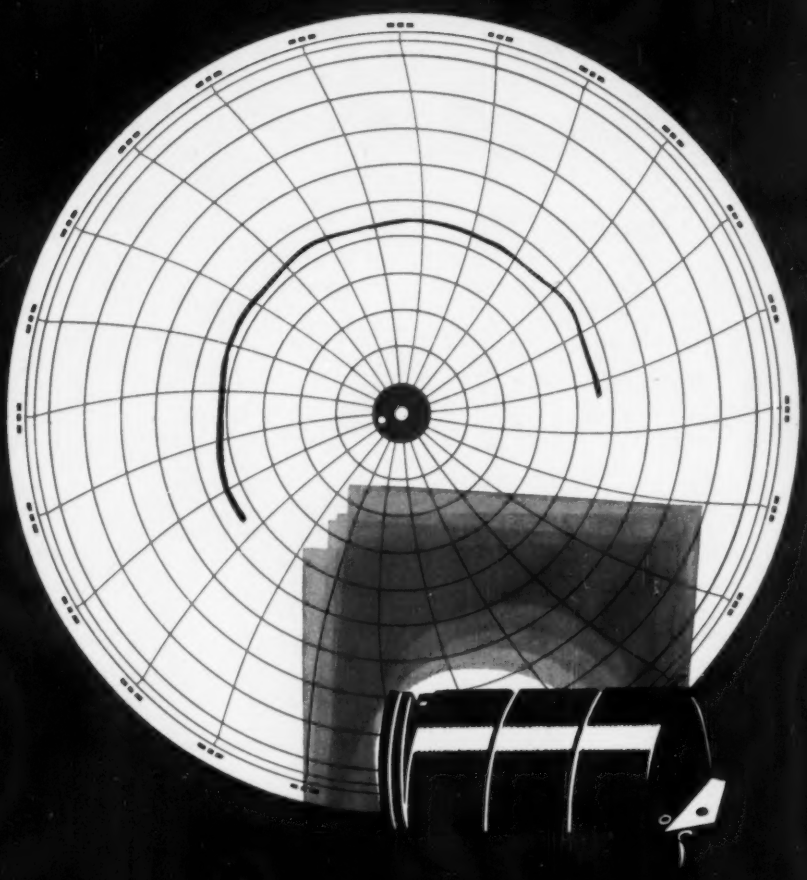
HONEYWELL



The New Honeywell Thermal System

withstands extreme vibration and corrosion conditions

Here's a new gas-actuated thermal system that takes the zig-and-zag out of temperature recording under severe vibration conditions.

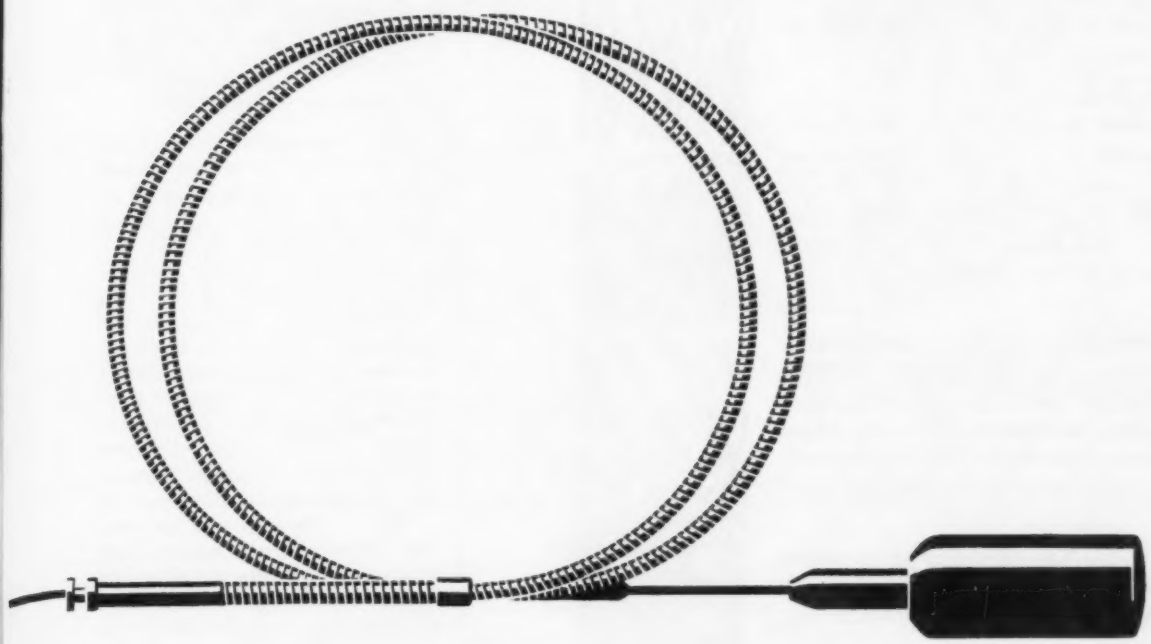
A complete series of vibration tests has proved the vibration resistance of the new Class III thermal system. In these tests, the Class III system was installed in a standard Honeywell rectangular case recorder, and subjected to forced vibrations in three mutually perpendicular planes. With accelerations up to 0.2G from 0 to 200 cps, maximum pen oscillation was limited to 1.5%. For more than 75% of the range, *pen oscillation was less than 0.5%!* . . . with no resonant effects at 60 cycles.

Check these many new design and construction features: high-energy helix for increased sensitivity and lower dead spot; built-in overrange or underrange protection; stainless steel bulbs to withstand corrosive atmospheres; low carbon 316 stainless steel linkages with low-friction, ball-joint construction; coarse and fine zero adjustments for easy settings.

Get the complete story on the new Class III Thermal System by contacting your nearby Honeywell field engineer today. He's as near as your phone. MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pennsylvania.

Honeywell

H HONEYWELL *First in Control* SINCE 1885



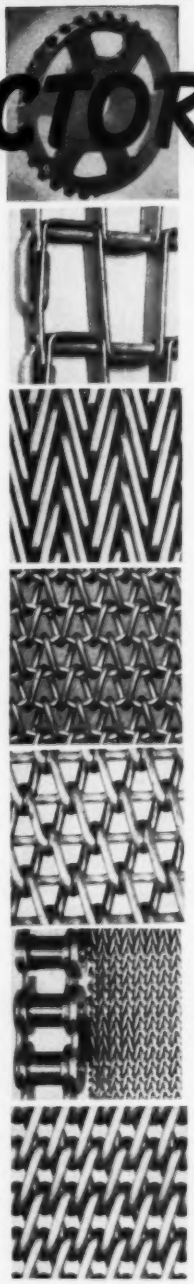
Circle 474 on Page 48-S

WHEN YOU SPECIFY

ASHWORTH METAL PROCESS BELTS

YOU GET

2-PLUS FACTORS



Complete *engineering versatility* PLUS the *finest plant and manufacturing facilities* in the industry insure customers of Ashworth Bros., Inc. two Big Plus Factors when they specify ASHWORTH METAL PROCESS BELTS for all of their continuous product flow installations . . . regardless of the product or the process.

Ashworth's new plant in Winchester, Virginia . . . devoted exclusively to the manufacture of Metal Process Belts . . . is modern in every detail . . . the most modernly equipped facility in the country.

Ashworth's emphasis on engineering excellence and versatility, combined with rigid quality control and product testing, have made Ashworth Metal Process Belts the standard throughout the entire metal process belt industry.

You, too, can depend on an Ashworth Metal Process Belt when faced with a problem of continuous product flow. Consult an Ashworth Field Representative . . . his knowledge, coupled with the experience and backing of this leader in the industry, will insure that you get the "Right Belt to do the Job Better". . . to keep your product on the move.

Technical literature on all Ashworth Metal Process Belts is available at no obligation, write:

ASHWORTH BROS., INC.

WINCHESTER, VIRGINIA

Sales Offices In Principal Cities

Circle 475 on Page 48-B

Metallurgical Progress...

this would be accompanied by faster diffusion rates. Consequently it has generally been assumed that a thermodynamically unstable structure, such as is obtained by cold working or age hardening, would be greatly changed by heavy irradiation. Since such "unstable" alloys always have better mechanical properties than stable structures, it is important to determine whether irradiation *does* affect the rate at which the unstable structure transforms to the stable.

To investigate this a considerable amount of work has been done on the effect of neutron irradiation at 280 and 380° C. (535 and 715° F.) on the mechanical properties of Zircaloy-2 cold worked 15%. So far no evidence has been obtained which shows that recovery from cold work occurs faster in the presence of a neutron flux.

Irradiation and Aging

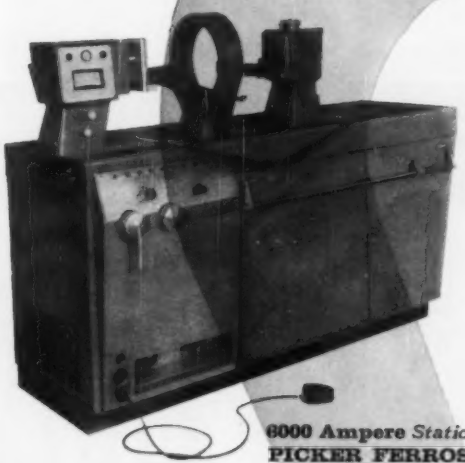
Other experiments have been made on the recovery of cold worked Al-Mg alloys, and rate of aging in Al-Mg-Si alloys (65 S). No effect of irradiation at 100° C. (212° F.) has been found. A more comprehensive investigation of the age hardening Cu-Be alloy gives the same results, although earlier work elsewhere showed that an incubation period was required before the solution-treated alloy began to harden at 300° C. (575° F.) while the same material began to harden immediately on post-irradiation annealing at 300° C. The earlier results probably resulted from a solution heat treatment wherein the rate of cooling was not fast enough to retain all of the beryllium in solid solution.

TEMPERATURE MEASUREMENTS

Industrial temperature measurement with thermocouple pyrometers, with total radiation and optical pyrometers, with resistance thermometers and filled systems thermometers. W. E. Belcher, Jr., D. Robertson, W. F. Hickes – *64 pages – 6 x 9 – illustrated – paper cover – $1.00.* Clip and send to ASM Technical and Engineering Book Information Service, Metals Park, Novelty, Ohio.

new look
(and greater efficiency)

in Magnetic Particle Flaw Detection Equipment



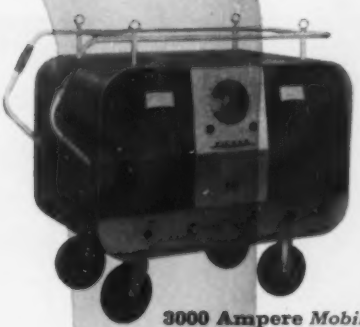
6000 Ampere *Stationary Model*
PICKER FERROSCOPE
for Wet Technics

new outside

- *Clean-lined modern design: easy to clean, easy to keep clean.*
- *Modular principle: units combine to handle parts up to 12 feet long.*
- *Meters and signals function-grouped at eye level.*

new inside

- *New heavy duty silicon full-wave rectifiers run cooler, quieter.*
- *Heat capacity five times greater than MIL Type II specs call for.*
- *Does away with noisy, grime-blowing exhaust fans.*



3000 Ampere *Mobile Model*
PICKER FERROSCOPE
for Wet and Dry Technics

new outside

- *Roll-to-the-job unit: companion design and same finish as big Ferroscope.*
- *Easy to read meters, husky control knobs.*

new inside

- *Same heavy duty cool-running silicon rectifiers as 6000 A. unit.*
- *Heat capacity fivefold greater than required by MIL Type III specs.*
- *Either AC or half-wave DC always on tap for best results with both wet and dry technics.*
- *Stepless current control up to 3000 A.*
- *All operation controllable at machine or by remote handswitch on long cable.*

For heavy duty inspection schedules, one or the other of these Ferroscopes may be just right for you. Or maybe a smaller Ferroflux or Portaflux portable magnetic particle inspection unit would be adequate to your lighter need. In any case, call in your local Picker representative: he will be glad to advise you about these, or any of the other nondestructive inspection systems Picker offers (they're listed below).

ONE STOP *for all this* ***in non-destructive inspection equipment***

x-radiography	**ANDREX** portable x-ray units-140 KV, 160 KV, 200 KV, 260 KV **PICKER** x-ray units—35 KV Beryllium window, 90 KV, 110KV, 150 KV (stationary and mobile), 270 KV portable
gamma radiography	**PICKER** ***Pipeliner***—30 curies, Ir^{193}, ***Cyclops***—1500 curies; Co^{60} **TECH/OPS** Iridium^{192} units from 10 to 100 curies; Cobalt^{60} 3 to 100 curies: also Thulium^{170}, Cesium^{137}
fluoroscopy	**PICKER** Image Intensifier and associated equipment
magnetic particle	**PICKER** ***Ferroscope*** ***Ferroflux*** ***Portaflux*** **PIXmag** Ferropowders and pastes
dye penetrant	**PIXchek** Penetrants, Cleaners, Developers, and accessories

Picker x-ray

PICKER X-RAY CORPORATION
25 South Broadway, White Plains, N. Y.

Circle 476 on Page 48-B

production carburizing

these exclusive Ipsen features guarantee the finest results for continuous production carburizing.

Enclosed Charging Mechanism (Pat. No. 2,894,770)

Chain Discharging Mechanism (Pat. No. 2,842,349)

Baffles for 100% Forced Convection Heating (Pat. No. 2,788,208)

Ceramic Heating Tube Mounting (Pat. No. 2,822,798)

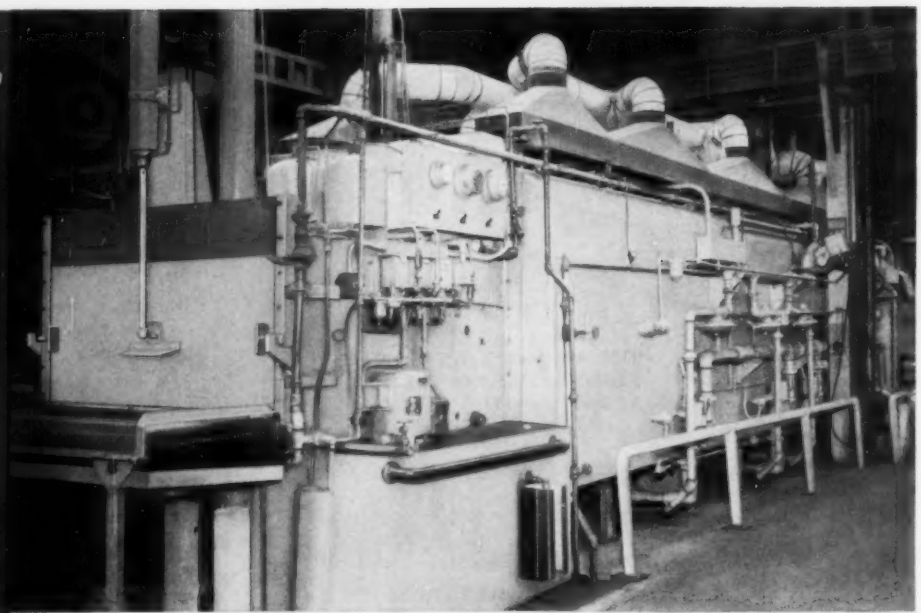
Ceramic "Flame-Busters" (Pat. No. 2,861,894)

Ceramic Fan (Pat. No. 2,730,352)

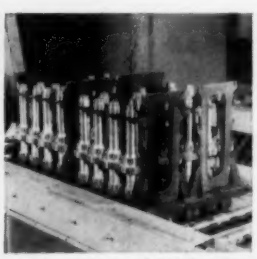
Water-Cooled Fan Motor (Pat. No. 2,800,317)

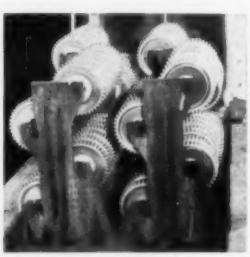
Quench Oil Flow System (Pat. No. 2,854,013)

Ipsen will build Production Carburizing Furnaces of any desired capacity to give similar results on any production work. Send for Bulletin P-59. Better yet, ask an Ipsen engineer to call and give you complete information relating to your work.



Ipsen 2P-12-2424-GM Double Row 4-Zone Pusher Furnace for Continuous Production Carburizing.





This charge of steel gears, and these countershafts, are typical of work which is being production-carburized in Ipsen furnaces.

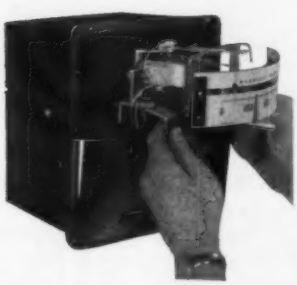
AUTOMATIC Ipsen HEAT TREATING UNITS

IPSEN INDUSTRIES, INC. • DEPT. 723 • P.O. BOX 500 • ROCKFORD, ILLINOIS

Circle 477 on Page 48-B

Ever try threading a needle
WITH ONE EYE CLOSED?

The interchangeable unit design of Wheelco Capacitrols provides the ultimate in control-instrument flexibility . . . permits on the job modifications to meet changing production demands.



TRYING to meet today's process control requirements with yesterday's instrumentation is like trying to thread a needle with one eye closed! Today's rigid processing demands the accuracy and flexibility of Wheelco Capacitrols. Why? Wheelco's interchangeable unit design (see left) for maximum flexibility permits on-the-job instrument modifications to meet changing production demands . . . plug-in chassis for fast servicing . . . a wide variation of control forms such as time-proportioning Capacitrols when system inertia compensation is necessary . . . or electric-proportioning Capacitrols for saturable core reactor control (a Wheelco first). Without qualification, Wheelco Capacitrols offer the most accurate and flexible process forms available. Ask your nearby Wheelco sales and service representative to give you complete data on all Wheelco instruments. After all, if you're using obsolete process control instrumentation, we both lose . . . right?

WRITE FOR COMPLETE ENGINEERING DATA

In addition, Wheelco Capacitrols offer exclusive "Electronic Link" no-contact control, flexibility of sensing elements, thermocouple break protection and many other advantages.

BARBER COLMAN

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Dept. A, 1518 Rock Street, Rockford, Illinois, U.S.A.
BARBER-COLMAN of CANADA, Ltd., Dept. A, Toronto & Montreal
Export Agent: Ad. Auriema, Inc., N.Y.

Circle 478 on Page 48-B

PERSONAL MENTION

W. O. Binder

W. O. BINDER, assistant director of development for Union Carbide Metals Co., was transferred to the Union Carbide Development Co. in October. With headquarters in Geneva, Switzerland, Mr. Binder will maintain contact with European steel industry in order to keep the company abreast of developments in the metallurgical industry.

A 1931 graduate of Case Institute of Technology with a degree in metallurgical engineering, he worked in the metallurgical department of Dow Chemical Co. until joining Union Carbide Metals Co.'s technology department in 1936.

He received the Henry Marion Howe Medal of A.S.M. in 1950 and served on the Publications Committee of A.S.M. from 1953 to 1955. He was also a contributor to the 1948 Metals Handbook and Corrosion of Metals, published by A.S.M.

His other technical affiliations include A.I.M.E. and A.S.T.M. (where he is on the Joint Committee on Effect of Temperature on Metals). He has also served as chairman of the High Alloys Committee of the Welding Research Council and chairman of the Western New York Section of the National Assoc. of Corrosion Engineers.

Ray Dhue, Jr. – transferred from Dallas, Tex., to Louisville, Ky., to serve as technical representative for this area for Parker Rust-Proof Co., Detroit.

Sam L. Hoyt – returned to his metallurgical consulting practice in Berkeley, Calif., after a 16-month assignment in Western Europe, where he surveyed the current research and developments in welding in NATO countries for the Department of Defense.

A. R. Spurlock – now vice-president and general manager of the Leukart Machine Co., located in Columbus, Ohio.

J. Ralph Patterson – from vice-president in charge of the Mackintosh-Hemphill Div., of E. W. Bliss Co., to president and chief executive officer of the parent company. **Charles E. Peterson**, formerly manager of manufacturing operations, Mackintosh-Hemphill Div., was named division manager, succeeding Mr. Patterson as chief executive.

Richard E. Reed – from Carnegie Institute of Technology to the staff of Oak Ridge National Laboratory, operated by Union Carbide Nuclear Co., Oak Ridge, Tenn.

James F. Reynolds – now sales representative for Hamler Industries, Chicago, in southern Illinois, northern Indiana, eastern Missouri and eastern Iowa.

William C. Stewart – joined J. Bishop & Co. platinum works, Malvern, Pa., as manager of the mechanical division.

Harry D. Wallach – from vice-president, nonferrous division of Frank Samuel & Co., to vice-president and general manager of Howe Refining Co., a subsidiary of Howe Sound Co.

Bruce C. Whitmore now a member of the metallurgy group in the research laboratory of the Tonawanda (N.Y.) Laboratories of the Linde Co., a division of Union Carbide Corp.

John A. West – from inside salesman, Riverside-Alloy Metal Div., H. K. Porter Co., Riverside, N.J., to field specialist for Superior Tube Co., Norristown, Pa.

Edgar J. Planz – from research metallurgist, Electric Boat Div., General Dynamics Corp., to associate professor of metallurgical engineering at the University of Alabama.

Alden P. Taber – elected a vice-president of Babcock & Wilcox Co. and placed in charge of the research and development division, in the B&W Research Center in Alliance, Ohio.

William M. Adler – from eastern region district manager for Blaw-Knox Co.'s National Alloy Div., Pittsburgh, to manager of sales for the division.

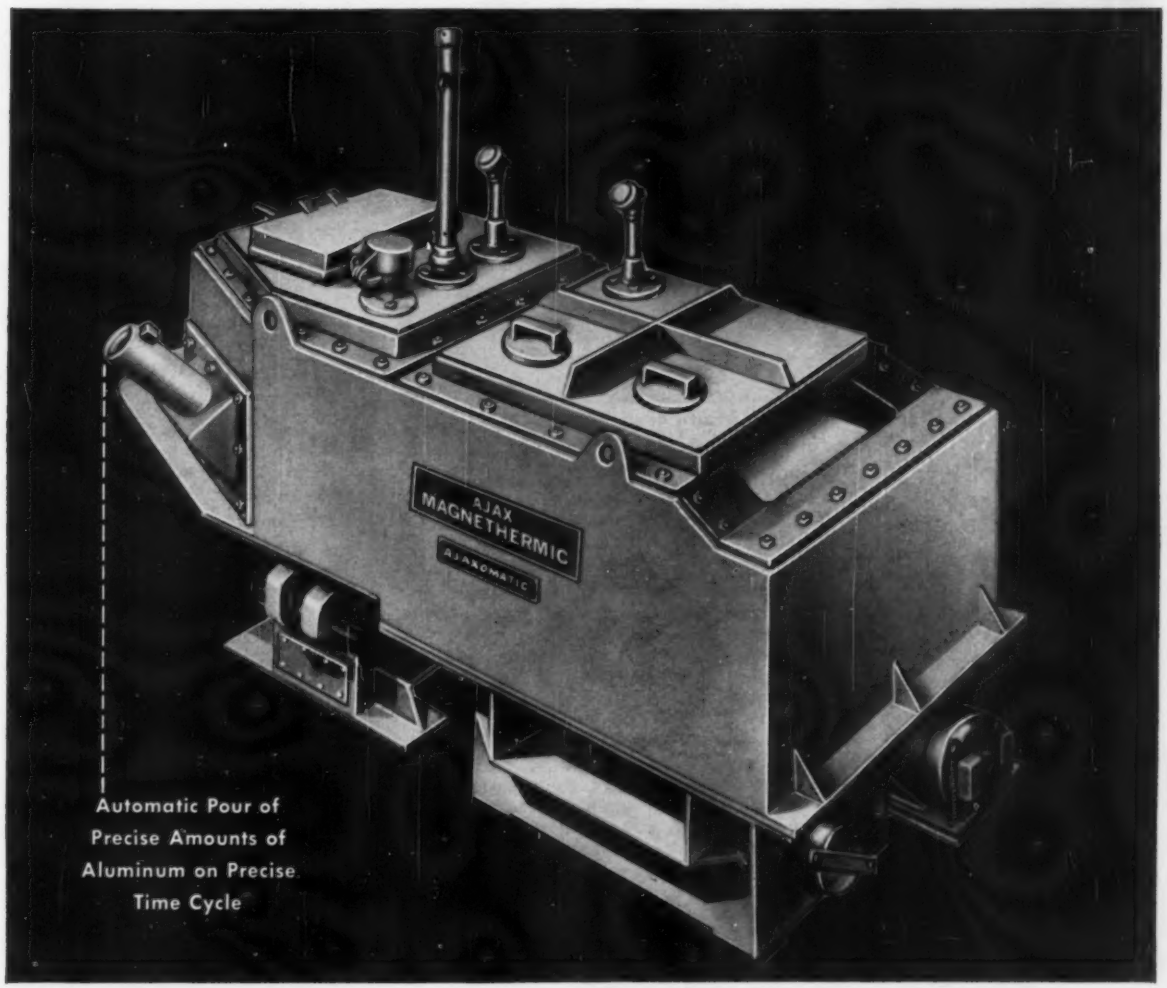
Marian Balicki, consulting metallurgist at the Knolls Atomic Power Laboratory of General Electric Co., Schenectady, N.Y. – named to full membership in the New York Academy of Sciences for his "sustained interest and creditable contributions toward the advancement of science".

Raymond F. Decker – from senior metallurgist to supervisor of nickel and stainless alloy research at the International Nickel Co. Research Laboratory in Bayonne, N.J.

Wylie J. Childs and **Warren F. Savage** – now full professors at the Rensselaer Polytechnic Institute, Troy, N.Y. At the same time, **John J. McCarthy** was named associate professor.

AJAXOMATIC pours molten aluminum automatically to die casting machines.

Use: Whenever high speed, high casting weight or high quantity requirements make hand ladling too slow or too costly. *How:* Ajaxomatic (60-cycle core type induction furnace) automatically supplies molten aluminum to the machine in any size "shot" on precise time cycle. *Experience:* There are many Ajaxomatics in use. Some of the largest die castings produced are poured with Ajaxomatic. *Inquiry:* Write direct to us for additional information on Ajaxomatic Automatic Pouring Furnace by induction.



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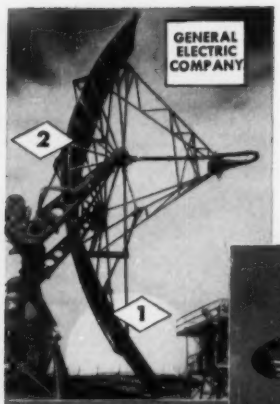
Circle 479 on Page 48-B

LOOK FOR THE DIAMONDS—SIGN OF FINISHING QUALITY

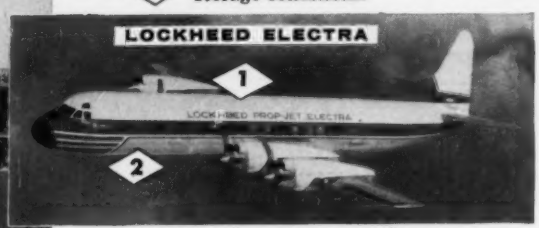
for protection on light metals

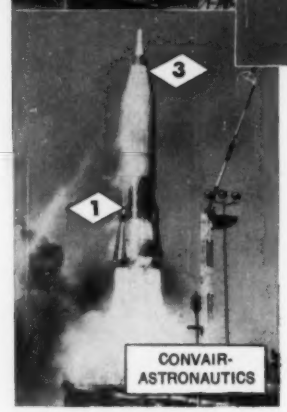
you need IRIDITE®

PROCESS ENGINEERED
CHROMATE CONVERSION COATINGS



1. Iridite protects against high altitude weather extremes and against corrosion by hydrocarbon fuels, such as gasoline and kerosene.
2. Iridite provides a highly protective non-porous paint base.
3. Iridite protects against corrosive storage conditions.





And, Iridite gives you these additional advantages:

ON ALUMINUM—needs only normal precleaning. Film withstands cold forming or bending. Easily heliarc welded. Unusually low electrical resistance. Clear, yellow or dye-colored finishes.

ON MAGNESIUM—short immersion, room temperature solution, no electrical equipment. Corrosion protection relatively unaffected by high drying temperatures. Applicable to all alloys. Low electrical resistance. Color ranges from light gray to dark brown.

IRIDITE—a specialized line of chromate conversion coatings for non-ferrous metals. Easily applied at room temperatures with short immersion, manually or with automatic equipment. Forms a thin film which becomes an integral part of the metal. Cannot chip, flake or peel; special equipment, exhaust systems or highly trained personnel not required.

For complete information on Iridite, contact your Allied Field Engineer. He's listed under "Plating Supplies" in the yellow pages. Or, write for FREE TECHNICAL DATA FILES.

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IRIDITE® Chromates | IRILAC® Coatings | ISOBRITE® Brighteners | ARP® Supplies | WAGNER Equipment

Circle 480 on Page 48-B

Personals . . .

Frank A. Baker, Jr. – from assistant general manager of the Sparrows Point, Md., plant of Bethlehem Steel Co. to chief engineer, steel division with headquarters in Bethlehem, Pa.

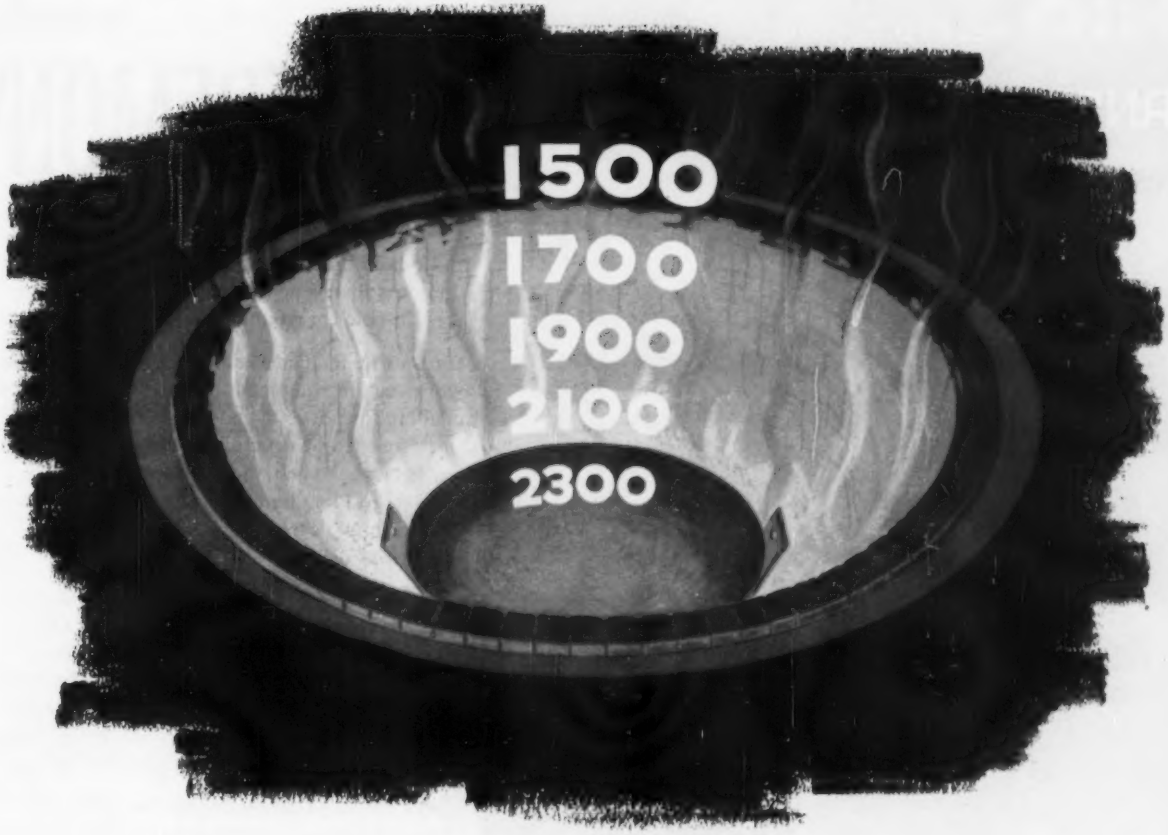
Edward N. Nelson – from manager of quality control to product manager, carbon and coated strip steels, at the Youngstown, Ohio, plant of Jones & Laughlin's Stainless and Strip Div. **William Brenner, Jr.**, service metallurgist at the Louisville, Ohio, plant, will succeed Mr. Nelson.

Clyde Williams, Clyde Williams and Co., Columbus – named to the Board of Directors of the Keinath Instrument Co., Columbus.

Roysel J. Cowan – retired as a pastor of the Free Methodist Church after twenty years as a minister. An ASMember for over 35 years, Mr. Cowan spent 30 years in industry as a chemist and metallurgist, (first with National Malleable and Steel Castings Co. and then Surface Combustion Corp., both in Toledo) before entering the ministry.

A. Allan Bates, vice-president of research and development, Portland Cement Assoc., Chicago, Ill. – nominated president of the American Society for Testing Materials. **Jerome J. Kanter**, directing engineer, materials engineering, for Crane Co., Chicago, was nominated as director of the Society.

Robert J. Painter, for some years executive secretary and treasurer of the American Society for Testing Materials, but who unfortunately has been incapacitated by a hip injury, has resigned to become consultant in the Society's long-range planning program. The new executive secretary is **Thomas A. Marshall, Jr.**, formerly senior assistant secretary of the American Society of Mechanical Engineers. **Fred F. Van Atta**, formerly assistant secretary of A.S.T.M., is now treasurer and business manager. **Raymond E. Hess** will continue his work as associate executive secretary and editor in chief of A.S.T.M. publications.



2300° HOT . . . *but not bothered!*

Retort made of HASTELLOY alloy X is removed from furnace after brazing cycle at 2300 deg. F.

RETORTS made of HASTELLOY alloy X and used for controlled-atmosphere brazing of rocket and missile parts at 2300 deg. F—last up to twice as long as retorts previously used. The alloy's high strength and resistance to oxidation and thermal shock make thinner walls possible. This in turn shortens heating cycles by 25 per cent . . . and cuts fuel costs by as much as 40 per cent.

Total savings during the 100-day lifetime of the retorts is about $1000—resulting from lower first cost, shorter heating cycles, 150 additional cycles per retort, and reduced costs for fuel and welding maintenance.

Resistance to stress, to thermal shock, to erosion, corrosion, and fatigue, are typical properties that make HAYNES alloys so extremely useful in jet engine turbine wheels, in ramjets, missiles, rockets, as well as industrial heat-treating applications.

Whether investment- or sand-cast, rolled, wrought, vacuum melted, or air melted, there's a HAYNES high-temperature alloy to meet your needs.

HAYNES ALLOYS

HAYNES STELLITE COMPANY

Division of Union Carbide Corporation

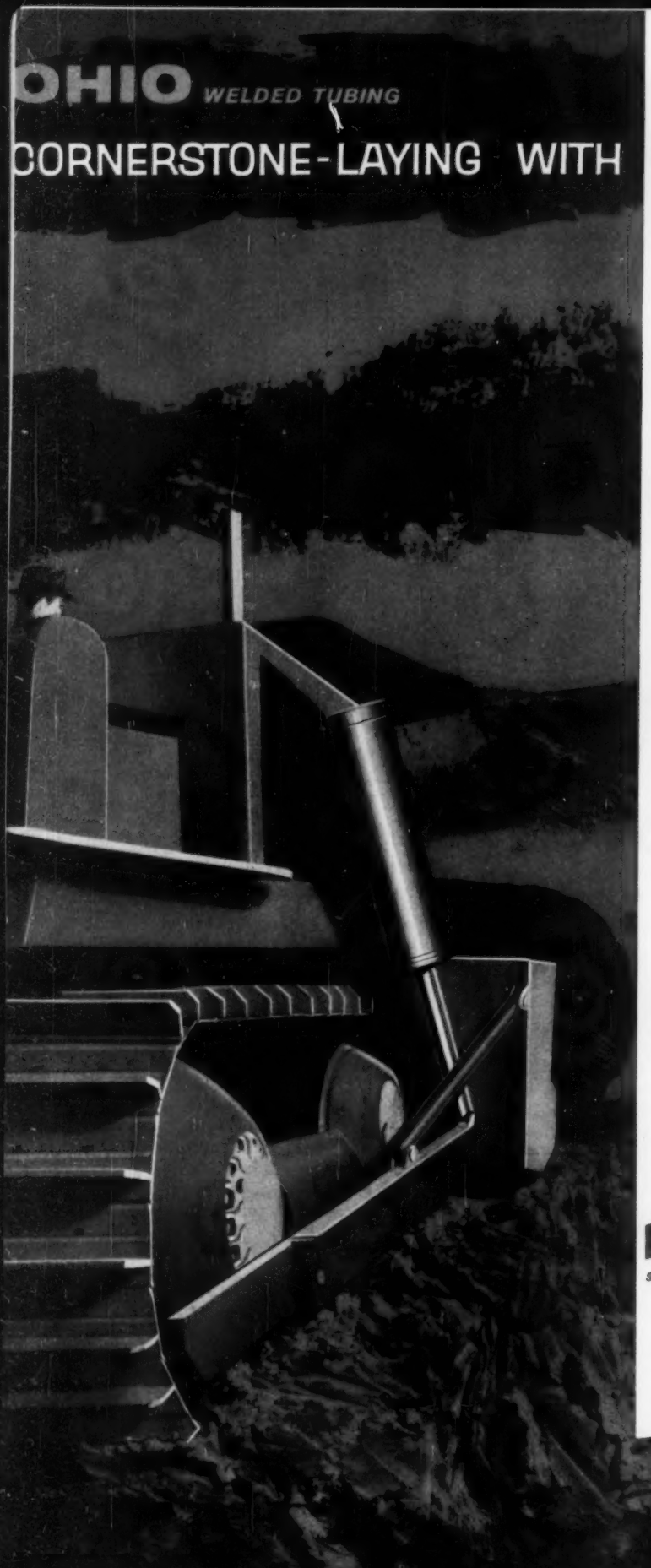
Kokomo, Indiana

UNION CARBIDE

Address inquiries to Haynes Stellite Company, 270 Park Avenue, New York 17, New York.

"Haynes," "Hastelloy," and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

Circle 512 on Page 48-B



OHIO WELDED TUBING

CORNERSTONE-LAYING WITH

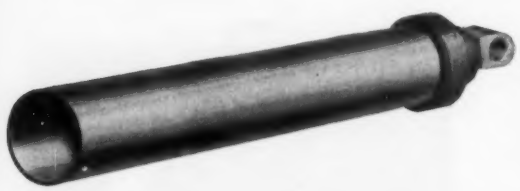
NO CEREMONY

In today's hustling, bustling construction business there's no time to stand on ceremony . . . no point in risking costly equipment failure.

To short-circuit mechanical downtime, leading construction equipment producers specify Ohio Tubing for power cylinders and fluid lines, mechanical and structural members. This gives equipment the heft and brawn to shrug off brutal, grinding punishment . . . gives equipment users a high degree of protection against disastrous delays.

You can strengthen your product — and its mechanical reputation — by specifying Ohio *Custom Made* Tubing. The name Ohio is the hallmark of the highest quality in tubing, both seamless and welded. And we're now able to deliver a broader range of welded tubing sizes, wall thicknesses and grades than ever before.

Let's not stand on ceremony. We want your tubing business — seamless to 7" OD, *welded up to 7½" OD.* For a fast start, contact your nearest Ohio representative, or send part drawings to the plant at *Shelby, Ohio—Birthplace of the Seamless Steel Tube Industry In America.*



Ohio Seamless offers the broadest parallel range of both welded and seamless quality steel tubing in the industry.

OHIO SEAMLESS TUBE

Division of Copperweld Steel Company • **SHELBY, OHIO**

Seamless and Electric Resistance Welded Steel Tubing • Fabricating and Forging

Representatives in principal cities. Check leading directories: THOMAS', MacRAE'S, CONOVER-MAST, SWEET'S, FRASER'S.

Circle 477 on Page 48-B

A-3305A

Personals . . .

William K. Hooper – from vice-president of the electrochemical division of Republic Foil Inc., Danbury, Conn., to the newly created position of vice-president, marketing.

Robert L. Humphrey – now sales representative for Alloys & Chemicals Corp., Cleveland.

Carolyn R. Irish, metallurgist in the thermal metallurgy section of the National Bureau of Standards – received a U.S. Department of Commerce Silver Medal for Meritorious Service for her "extremely competent and conscientious work in the field of physical metallurgy".

Gabor Koves – on a year's leave of absence from International Business Machines Corp., Rochester, Minn., to study (under an I.B.M. scholarship) for an M.S. in metallurgical engineering at Illinois Institute of Technology.

Donald J. Kabler – now sales representative in the Chicago district for Vulcan-Kidd Steel Div., H. K. Porter Co., Aliquippa, Pa.

Thomas J. Kelly – now assistant director, international services, Raytheon Co., Waltham, Mass.

O. Kobel – now vice-president, Air Reduction Canada Ltd., Montreal, Que.

Homer Clarkson Lacey, manager, forged products, U. S. Steel Corp., Pittsburgh – elected president, director and chief executive officer of Erie Forge & Steel Corp.

Donald J. Legacy – from Virginia Polytechnic Institute to the staff of the Oak Ridge Y-12 Plant, Union Carbide Nuclear Co., Oak Ridge, Tenn.

H. P. Leighly, Jr. – from research metallurgist at the Denver Research Institute, in charge of the instruction of metallurgy at the University of Denver, to associate professor of metallurgical engineering at the Missouri School of Mines and Metallurgy.

I. W. Wilson – from chairman of the board of directors of Alcoa Aluminum Co. of America, Pittsburgh, to chairman of the company's Finance Committee.

Chace THERMOSTATIC BIMETAL
Actuates Another Precision Product...

Here's a fine product which adds to the comfort and safety of the home. There's a secure feeling developed when—after having been away from home all day—you come home in darkness to find a brightly-lighted house waiting for you. No stumbling and fumbling in the dark either, thanks to PROTECT-O-LITE made by Energy Kontrols, Incorporated. This thermal switch photo electric eye turns on the light at dusk, turns it off at dawn. The absence or presence of light causes the electric eye to energize or degenerize a resistor, causing the working bimetal to bend and actuate the control switch. A time delay eliminates false operation due to momentary flashes of light or temporary cloud movements. The PROTECT-O-LITE is not a photorelay . . . Chace Thermostatic Bimetal serves as the actuator, doing two jobs: it drives the switch as well as providing the time delay. The PROTECT-O-LITE is temperature compensated over a range of −25°F to +150°F. The ambient compensator, also made of Chace Thermostatic Bimetal, assures dependable operation of PROTECT-O-LITE at any temperature.

Like many other respected companies, Energy Kontrols assures the extreme dependability of its products. The dependability of PROTECT-O-LITE is greatly affected by two small pieces of Chace Thermostatic Bimetal. But this is a familiar responsibility at Chace. In more than a third of a century of specializing in thermostatic bimetal, Chace has become recognized for the utter dependability of its only product: precision thermostatic bimetal.

SEND NOW FOR OUR NEW "INFORMATION BOOKLET!" It contains many well illustrated pages of valuable design data and examples of successful applications of bimetal. More than 40 types of Chace Thermostatic Bimetal are available in coils, strips and completely fabricated elements of your design.

IT BENDS WITH THE HEAT
W. M. CHACE CO.
Thermostatic Bimetal
1626 BEARD AVE., DETROIT 9, MICH.

Circle 514 on Page 48-B

Personals . . .

C. W. Cockrum – now sales representative for the Metal Industries Div. of the Diversey Corp., Chicago, with headquarters in Kansas City.

Ralph P. DeVries – from supervising process metallurgist, air and induction vacuum melting, to technical assistant to the manager of quality control, Watervliet (N. Y.) Works, Allegheny Ludlum Steel Corp., Pittsburgh.

Stewart M. DePoy – now manufacturing representative for Hyper Alloys, Inc., and Frank W. Faery Co., both in Detroit, operating from South Euclid, Ohio.

James E. Thompson – from Montana School of Mines to the staff of the Oak Ridge Y-12 Plant, operated by the Union Carbide Nuclear Co., Oak Ridge, Tenn.

James R. Hunt – transferred from the Los Angeles district office to the Wilmington, Del., district office of the International Nickel Co., Inc., New York.

Harold W. Paxton, associate professor of metallurgical engineering, Carnegie Institute of Technology – received the $2000 Bradley Stoughton Award (formerly called the A.S.M. Teaching Award) given to outstanding young teachers in metallurgy.

Charles W. Phillips – from supervisor of process and mechanical metallurgy section to manager of research services department at Ford Motor Co.'s Scientific Laboratory, Dearborn, Mich.

George E. Barker – now vice-president and director of research at Van Straaten Chemical Co., Chicago.

Joseph V. Bosco – from senior metallurgist, special metals, West Leechburg (Pa.) Works of the Allegheny Ludlum Steel Corp., Pittsburgh, to supervisor of testing in the metallurgical laboratory of the Work's quality control department.

Andrew Lamberson – from technical supervisor in the quality control department's openhearth division at the Colorado Fuel and Iron Corp.'s Pueblo (Colo.) plant, to product supervisor, eastern zone for the department. At the same time, **Harold Newton** was promoted from technical supervisor to product supervisor, Colorado zone, for the quality control department.

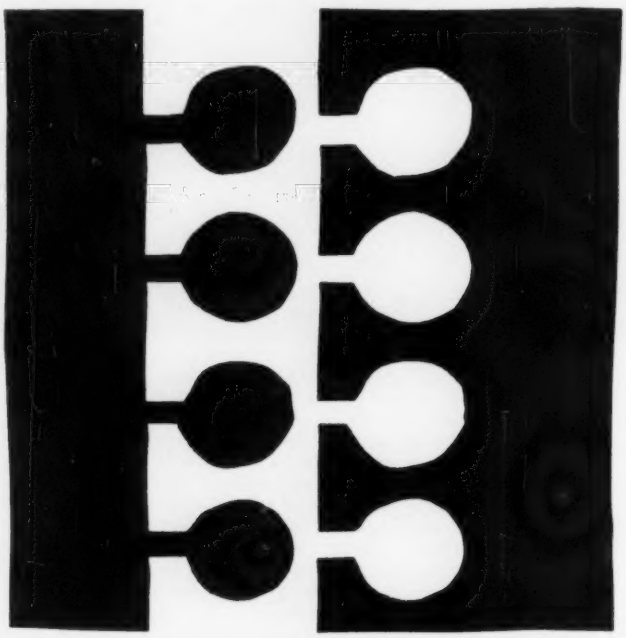
W. R. Keough – now mechanical engineer specializing in the design and construction of atmosphere furnaces for Commercial Heat Treating Corp., Detroit.

Raymond W. Gilbert – now eastern district manager of refractory metals development for Climax Molybdenum Co., New York, a division of American Metal Climax.

Charles H. Prince – now manager, technical service, in the metal division of the New Jersey Zinc Co., New York.

Kenneth L. Kojola – transferred from the U.S. Naval Weapons Plant, Washington, D.C., to the applications laboratory of Wright Air Development Div., Wright Patterson Air Force Base, Ohio, as research materials and development engineer.

John H. Gilman – from General Electric Research Laboratory, Schenectady, N.Y., to professor of engineering, Brown University.



super accuracy on complex parts

Need tolerance of 1/100,000″? Machine it!

But for many alloy parts requiring accurate shape, investment casting is the economical answer. We'll make most any shape to your specs—and maintain accuracy throughout.

If you're intrigued, dispatch a sketch of the part to Westinghouse Electric Corporation, Metals Plant, Blairsville, Pa. We'll take it from there. Shell-mold and vacuum casting also available.

J-05014

Westinghouse investment casting minimizes machining yet maintains required tolerances on this unloading comb that must match a mating piece.

You can be sure . . . if it's

Westinghouse

Circle 515 on Page 49-S

One of a series.

Why we eliminated the earth's magnetic field... almost

In an isolated laboratory in southwestern Ohio, GM Research scientists have reduced the earth's magnetic field to one ten-thousandth of its usual strength. This is about as weak as the interplanetary field detected by the Pioneer V solar satellite.

Why neutralize the earth's field? To perform with precision one of the more fundamental experiments in magnetism — measuring the Einstein-DeHaas effect. The measurement is simple in concept, experimentally difficult because of the tiny forces involved. It is made by suspending a ferromagnetic rod in a nearly field-free environment . . . magnetizing the rod . . . then measuring the effect (how much the rod rotates) when this known magnetization is reversed.

The beauty of the experiment is that the resulting values can be related directly to the motions of electrons in the rod. The values indicate the large portion of magnetfzation due to the *spin* of electrons . . . and the slight, but theoretically important, remaining portion due to *orbital* motion of electrons.

These measured values are helping scientists form a better understanding of the perplexing phenomenon — ferromagnetism. Currently being pursued in cooperation with the Charles F. Kettering Foundation, this long-standing project is one of the ventures in basic research of the General Motors Research Laboratories.

General Motors Research Laboratories

Warren, Michigan

Gyromagnetic Ratios

	a	***b***
Iron	*1.92*	*1.90*
Cobalt	*1.85*	*1.83*
Nickel	*1.84*	*1.83*
Supermalloy	*1.91*	*1.91*

Comparison of (a) gyromagnetic ratios measured in the new Kettering Magnetics Laboratory with (b) corresponding ferromagnetic resonance measurements. These ratios would equal 2 if magnetization were due only to electron spin, or 1 if due only to orbital electron motion.

System of Helmholtz coils used to neutralize earth's magnetic field.

Circle 516 on Page 48-B

Personals . . .

Frank O. Beuckman – development engineer in the roll coating division of Eastman Kodak Co., Rochester, N.Y. – elected third vice-president and a member of the executive board of the American Electroplaters' Society.

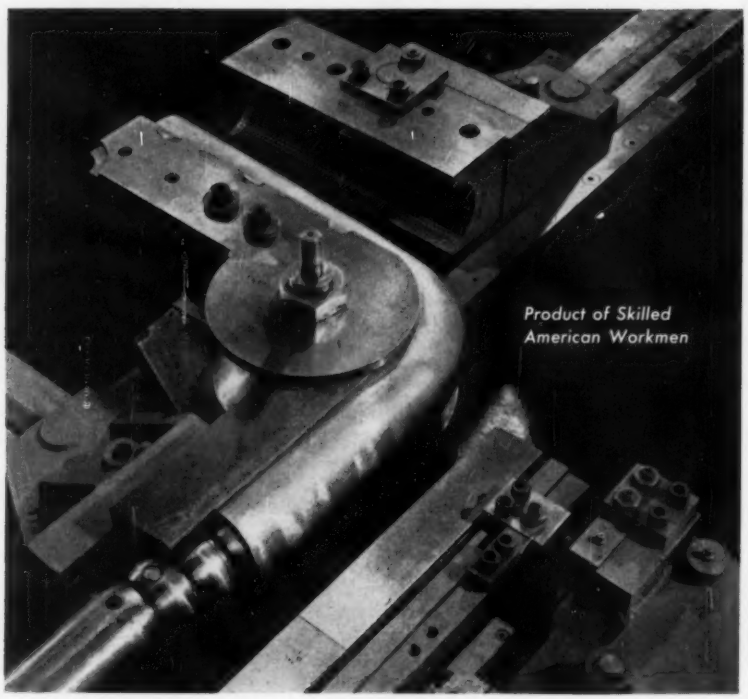
Walter W. Edens – from supervisor of metallurgical research to assistant director of the research division, Allis-Chalmers Mfg. Co., Milwaukee, Wis.

Charles W. Fox – from Virginia Polytechnic Institute to the staff of the Oak Ridge National Laboratory, operated by Union Carbide Nuclear Co., Oak Ridge, Tenn., as metallurgist.

A. Herbener – from manager of the Cincinnati district of Union Carbide Metals Co., New York, to manager, Pittsburgh sales district.

Martin H. Pollack – now sales and development engineer, Sethco Mfg. Corp., Merrick, L.I., N.Y.

COLUMBIA
TOOL
STEELS



TOOL STEEL IN USE: Tooling for Tube Bending Operation

Operation makes wrinkle-free bend on 3½" centerline radius with .020" thick aircraft quality 3" diameter stainless steel.

Three ball mandrel and wiper die are of SUPER-DIE. Bending, form and clamp dies are of E-Z-DIE.

It Pays to Use Good Tool Steel

COLUMBIA TOOL STEEL COMPANY
440 Lincoln Highway
Chicago Heights, Illinois

Hugh L. Logan, physicist, corrosion section of the National Bureau of Standards – awarded a U.S. Department of Commerce Silver Medal for Meritorious service for "exceptional achievement in metallurgy, particularly in researches into the stress-corrosion cracking of metals".

Alfred Eisenlohr – from General Electric Co.'s Flight Propulsion Laboratory, Evandale, Ohio, to manager of plasma bond division of Thermal Dynamics Corp., in Lebanon, N.H.

Daniel A. Hackett – from the Cleveland district of Vanadium Corp. of America, to the Detroit district as assistant district manager.

John E. Krickl – now western district sales manager for Lindberg Engineering Co., Chicago, with headquarters in Downey, Calif.

John B. Newkirk – from research associate in the metallurgy and ceramics department of General Electric Research Laboratory, Schenectady, N.Y., to professor of chemical and metallurgical engineering at Cornell University.

Robert D. Leslie – from assistant manager of the St. Louis sales branch of Crucible Steel Co. of America, Pittsburgh, to manager of the sales branch in Charlotte, N.C.

Neil Metcalf – from assistant to the general manager to assistant general manager, Burlington Steel Co. Ltd., Hamilton, Ont.

Carl R. Smith – now sales representative in the Kentucky-Tennessee territory, with headquarters at Louisville, for Hanson-Van Winkle-Munning Co., Matawan, N.J.

William R. Opie – from research supervisor of the geochem and metallurgical department, Titanium Div., National Lead Co., South Amboy, N.J., to manager of research for the Carteret, N.J., Laboratory of Amco Research & Development, Inc., a subsidiary of American Metal Climax, Inc., New York.

Irwin A. Binder – from vice-president, manufacturing, for the Ramo-Wooldridge Div. of Thompson Ramo Wooldridge Inc., Cleveland, to vice-president, main plant operations, for the automotive divisions at company headquarters.

FOR SHEER, SHEAR STRENGTH

Hydraulic Pressure tests on Bridgeport Brass Company's patented cladding system show perfect no-leak bonds over 3000 psi.

...*Bridgeport Brass Uses EASY-FLO 45 to Bond Their Clad Metals*

The "thick and thin" of cladding—from .010 to 2¾" in a combination of ferrous and non ferrous metals—calls for a bonding agent that will hold under the most severe forming and service operations. The answer, in every respect, is Handy and Harman's silver brazing alloy, EASY-FLO 45.

The uses to which these clad metals are put range from the kitchen to power plants, refineries, chemical and food-processing installations. Famous Bridgeport Copperware, used by housewives throughout the country, is made from a triple-clad metal consisting of a sandwich of two sheets of .010 stainless steel bonded to both sides of a sheet of .025 copper. The metals are joined in Bridgeport's patented process at *finish gauge*. So strong is the bond that no difficulty is encountered in the forming operations which follow.

Tube sheets, though their uses are far from "domestic," require the same "bondability." Tests at Bridgeport show that shear strength exceeds 20,000 psi. And this involves the cladding of carbon steel to as many different metals as stainless, brass, Monel and copper.

The primary need here, of course, is strength. EASY-FLO 45 has other attributes that are more than welcome under *any* metals-joining conditions: thermal and electrical conductivity, gas- and liquid-tightness, ductility, ease of application and economy are some more that we'd like you to know more about. We are ready indeed to further acquaint you with the significant benefits of silver alloy brazing by sending you our Bulletin 20, which is a clear and comprehensive introduction to one of the simplest, *saving* metals-joining methods in existence. Handy & Harman, 82 Fulton Street, New York City 38.

Your No. 1 Source of Supply and Authority on Brazing Alloys

HANDY & HARMAN

General Offices: 82 Fulton Street, New York 38, New York

Circle 517 on Page 48-B

Metals Engineering Digest

. . . Interpretative Reports of World-Wide Developments

Impurities in Aluminum Alloys

Digest of "Precipitation Effects in Liquid Aluminum Alloys", by N. D. G. Mountford and R. Calvert, *Journal* of the Institute of Metals, Vol. 88, 1959-1960, p. 121-127.

STUDIES HAVE SHOWN that oxide films and other heterogeneous impurities that have accumulated may be a major cause of casting defects in aluminum alloys melts. To investigate this, an ultrasonic technique can be used to locate oxides and precipitated phases. The authors show how this technique improved foundry performance.

The apparatus (which was a standard inspection equipment) consisted of a cathode-ray tube with deflection modulation and controls for time base, picture shift and receiver volume. Transducer crystals (½ in. diameter) were of barium titanate, and operated at a frequency of 2½ megacycles per sec. They were held in special probes which were screwed on to the end of special steel guide rods 1 in. in diameter and water cooled at their upper end. A separate transmitter and receiver system was necessary because reflections from within the body of the steel guide rods would overcome any reflections returning from the liquid metal. A diagram of the equipment is shown in Figure 1.

All of the material examined was

Fig. 1 – Diagram of Equipment

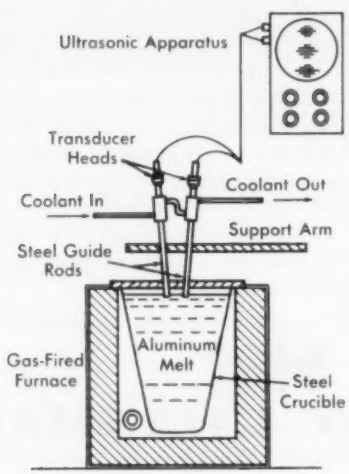
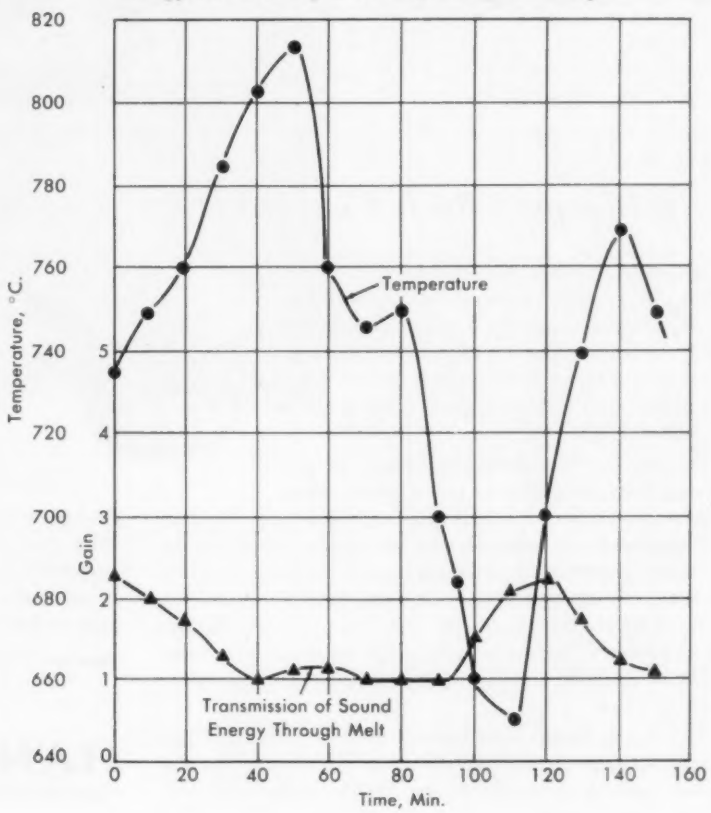


Fig. 2 – Variation With Temperature of the Sound Energy Absorbed by a Melt of Aluminum Alloy



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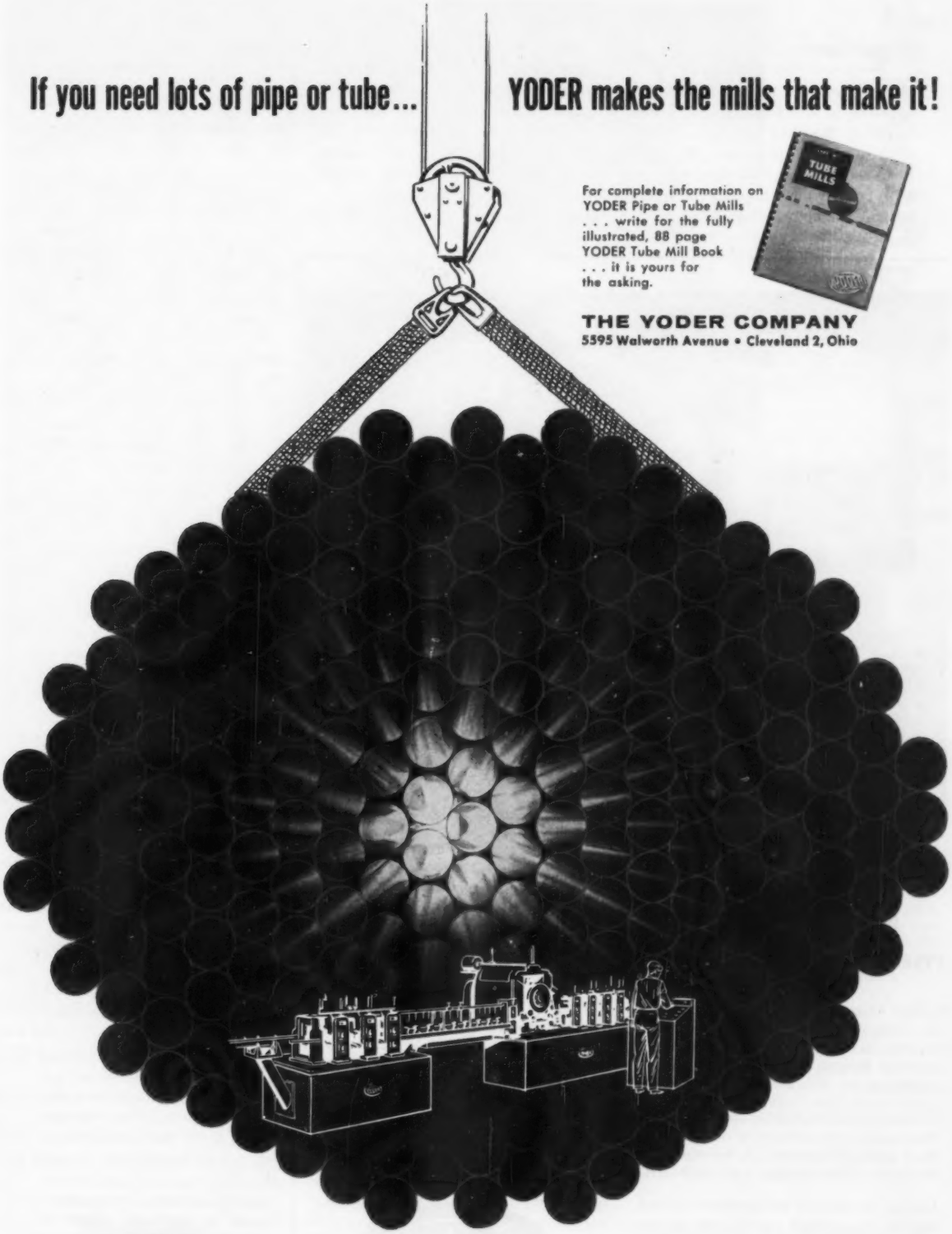
For complete information on YODER Pipe or Tube Mills . . . write for the fully illustrated, 88 page YODER Tube Mill Book . . . it is yours for the asking.

THE YODER COMPANY
5595 Walworth Avenue • Cleveland 2, Ohio



ENGINEERING
YODER
MANUFACTURING

PIPE AND TUBE MILLS (ferrous or non-ferrous)

COLD ROLL FORMING MACHINES

ROTARY SLITTING LINES

Circle 518 on Page 48-8

Impurities . . .

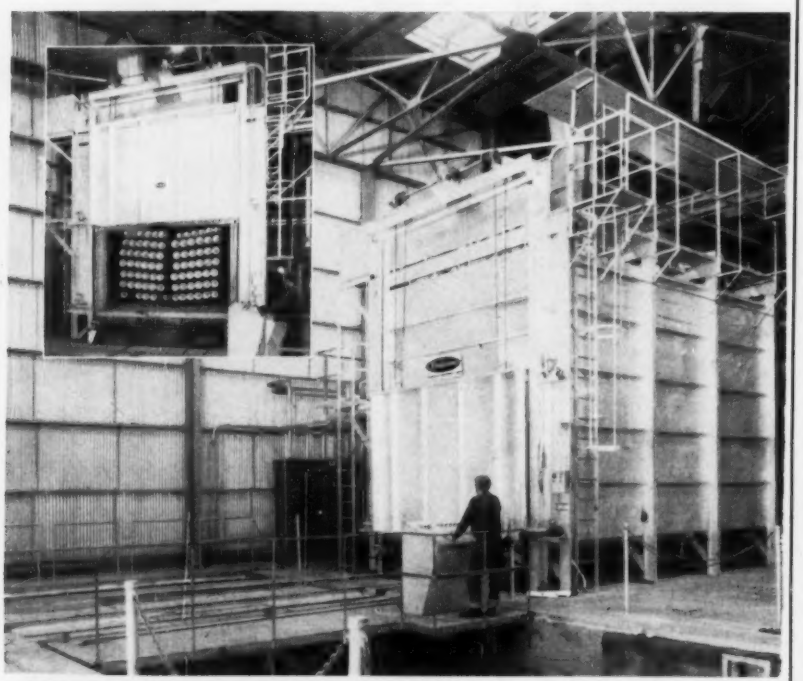
tapped from the normal production furnaces in the foundry and transferred to the steel crucible. Before each series of experiments, the ends of the steel guide rods were covered with brazing alloy to assist "wetting" by the aluminum alloy. The guide rods were immersed in the melt to about ½ in.

The pulse corresponding to any particular echo from the melt could be displayed on the cathode-ray tube screen. Its amplitude was measured by determining the setting of the instrument gain control required to make the observed pulse height equal to a preset datum value. The first indication of any sound energy reflected from the melt was in the form of small reflections at a point coincident in terms of sound-travel time with the immersed ends of the guide rods. A large signal was generally obtained from the bottom of the crucible. On stirring the melt, the effect of scattering of the sound pulses was easily noted. The amplitude of the bottom reflection diminished appreciably and the amplitude of reflections from the melt increased. In certain instances where the melt could be described as "dirty", complete elimination of the bottom signal could be obtained.

In every instance after stirring, strong signals of fluctuating amplitudes were observed from the body of the melt. The order of magnitude of the reflecting particles was 0.10 in. When the melt was allowed to stand at about 750° C. (1380° F.), there was an apparent cleaning of the liquid metal. Re-stirring the melt again gave rise to an increased amplitude. Some permanent improvement was, however, noted when melts had been heated to 900° C. (1650° F.). Lowering the temperature of a melt had no effect until a certain temperature, consistent for a particular analysis, was reached. This behavior is shown in Fig. 2 and corresponds to the precipitation of intermetallic compounds. Pure aluminum did not show this behavior.

The description of the ultrasonic technique and concurrent metallographic work by the authors is very well explained and illustrated by microphotographs. They were able to show that trouble in castings due to a special type of draw was related to the precipitation of intermetallic compounds in aluminum alloys RR 50 (1% Cu, 0.1% Mg, 2.5% Si, 1% Fe, 0.2% Ti), RR 250 (5% Cu, 1% Ni, 0.2% Ti, 0.25% Mn, 0.25% Co, 0.25% Sb) and RR 350 (5% Cu, 1.5% Ni, 0.2% Ti, 0.25% Mn, 0.25% Co, 0.25% Sb, 0.2% Zr).

Foundry technique was altered to prevent the melt temperature from falling below the critical temperature when cold ingots were charged into the semirotary oil-fired furnace. The melting furnace temperature was raised to 820° C. (1500° F.) for RR 250 and RR 350, and 800° C. (1470° F.) for RR 50. Troubles due to excessively high gas pickup at these higher temperatures were corrected by adding hexachlorethane degassing tablets or by increasing



Sunbeam Aluminum Homogenizing Furnace, Kaiser Aluminum & Chemical Corporation, Chalmette Works, La. (Inset) Charge view shows loaded furnace car inside furnace.

New *Sunbeam* furnace helps Kaiser meet expanding demand for Aluminum

Kaiser Aluminum & Chemical Corporation recently added this new Sunbeam heat processing furnace to help meet the growing demand for high quality Kaiser Aluminum.

Installed at Kaiser Aluminum's Chalmette Works, La., the furnace is divided into three zones of control. It homogenizes aluminum billet quickly and uniformly.

Among the furnace equipment's unusual features is a special transfer car system which brings the billet to and from the furnace car for easy loading and unloading operations. Other equipment built and supplied by Sunbeam includes a pre-wired control panel and a power panel.

What about your expansion plans? Kaiser Aluminum's new homogenizing furnace is an example of Sunbeam's leadership in building furnaces to supply a company's expansion needs. Why not let us help you meet the expanding demand for your aluminum products. Write or phone Sunbeam Equipment Corporation, 194 Mercer Street, Meadville, Pennsylvania.

For any heat process, see

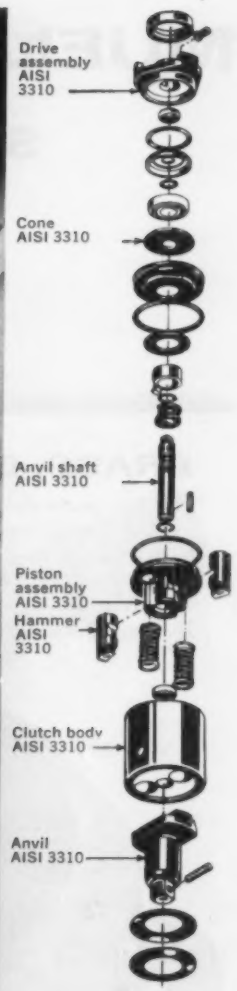
Sunbeam

The Best Industrial Furnaces made

SUNBEAM EQUIPMENT CORPORATION • Meadville, Pa.

Circle 519 on Page 48-B

Strong, tough Nickel alloy steel parts stand up to severe shock as Gardner-Denver impact wrench brings nut-and-bolt assembly up tight as a weld.



Exploded view of Gardner-Denver Model 18B-9 impact wrench reveals vital parts made from AISI 3310 Nickel steel for impact resistance.

Hard-hitting impact wrench lasts longer, thanks to 3½% Nickel alloy steel parts

Each time the socket slams against the faces of a big square or hex nut, seven vital parts of this Gardner-Denver impact wrench sustain the same sharp, powerful blow they deliver.

For built-in resistance to this repeated wear, shock-loading and torsional stress, engineers at Gardner-Denver specify AISI 3310 alloy steel (3½% Nickel) for *all* seven components that bear the full brunt of this battering:

- Drive assembly
- Cone
- Anvil shaft
- Piston assembly
- Hammer
- Clutch body
- Anvil

All these parts, made from carburized and hardened 3½% Nickel alloy steel, develop a hard, wear-resistant case backed up by a strong, tough core for resistance to countless shocks.

Typical core properties developed by heat-treated AISI 3310 steel:

Tensile strength	170,000 psi
Yield point, min.	140,000 psi
Elongation	15% in 2"
Reduction in area	60%
Brinell hardness	360

When you design, order, or use heavily stressed machine components, remember that Nickel alloy steels take the tough jobs in stride. For engineering data to help you select the best materials for specific applications, just write. We'll be glad to help.

THE INTERNATIONAL NICKEL COMPANY, INC.

67 Wall Street INCO New York 5, N. Y.

INCO NICKEL

NICKEL MAKES STEEL PERFORM BETTER LONGER

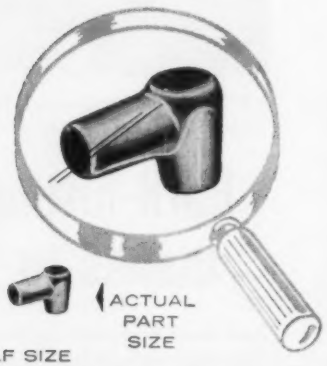
MUELLER BRASS CO. PRODUCES

SPECIFICATIONS . . . *REGARDLESS OF*

To obtain the desired physical and design requirements in a part at the lowest cost, there is usually one specific process by which that part can be most successfully and economically manufactured. Because the Mueller Brass Co. offers a variety of production methods, you get sound engineering, accurate production method analysis, our assurance of getting the best product at the lowest cost . . . regardless of metal specified or the size of your particular part.

BRASS, BRONZE, ALUMINUM FORGINGS

The two parts shown here dramatically illustrate the ability of the Mueller Brass Co. to produce precision forgings regardless of size or configuration. Both the tiny dental drill nozzle and the big heat exchanger shell hub, which is the largest of its kind ever produced, were forged to exacting specifications. The weight of the nozzle is only a few ounces while the shell hub weighs 40 lbs., and has a forged pocket 7 1⁵⁄₁₆″ in diameter and 4³⁄₁₆″ deep. By way of size comparison, the pocket is big enough to hold over 14,000 of these tiny drill nozzles. By forging the pocket, considerable machining time and money was saved. The sound, dense structure of the shell hub makes it ideal for the high pressure application for which it was designed. The forging not only does the job better, but was produced for 25% less than the casting it replaced. Experience makes it possible for the Mueller Brass Co. to produce high quality precision forgings regardless of specifications . . . why not put this experience to work for you?



ONE DEPENDABLE

Write today for Engineering Bulletins on any of these Products.

SCREW MACHINE PRODUCTS

POWDERED METAL PARTS

MUELLER BRASS CO.

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PARTS ECONOMICALLY...TO EXACT

METAL, METHOD OR SIZE...

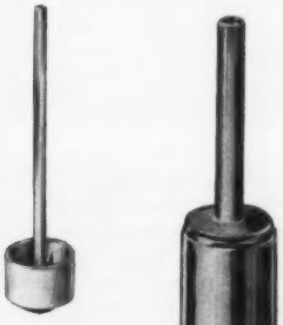
When you are designing, specifying or purchasing fabricated parts, call in the "Man From Mueller Brass Co." to help lower costs and improve your products. Sales and engineering service is available to you at Mueller Brass Co. offices throughout the United States. Make Mueller Brass Co. your one dependable source for all your part needs.

COLD PREST® IMPACT EXTRUSIONS

Today, because of vast experience in alloys, the Mueller Brass Co. has greatly expanded the possibilities of parts production by the impact extrusion method. Aluminum, of course, has been successfully used for a multitude of tubular shapes. But now it is also possible to impact parts of copper alloys incorporating such major advantages as: closer tolerances, better finish and appreciable metal savings. Because of dimensional accuracy possible with the impact extrusion, the necessity of secondary machining operations is often eliminated.

The parts shown here are representative of the group now being economically produced as impact extrusions by the Mueller Brass Co. who offer complete engineering and design service in the development of new parts from copper base alloys.

90-10 Copper Nickel Alloy



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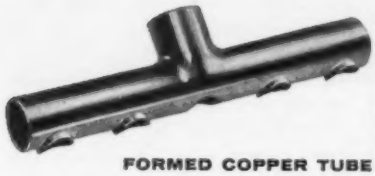

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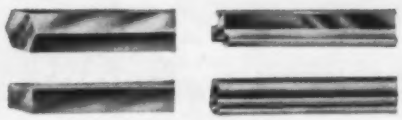

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Circle 520 on Page 48-8

Impurities . . .

the time of nitrogen degassing. Any excessive grain coarsening may be corrected by controlled additions of titanium and boron grain-refining compounds.

The technique described by the authors certainly appears extremely useful and one should consider its usefulness in other alloy systems.

W. A. MORGAN

Die Casting in a Vacuum

Digest of "Causes and Effects of Die Casting Porosity" and "The Die Casting of Metals Under Vacuum", by H. K. Barton, *Machinery*, Vol. 94, March 25, 1959, p. 673-684; April 29, 1959, p. 967-979.

THE FIRST PAPER discusses the various causes and possibilities that would result in porosity in die castings produced by conventional pressure casting techniques. According to the author the solution is vacuum die casting. Because of the many factors involved, the porosity found in two entirely separate castings could be attributed to completely different set of causes. Hence, this paper does not give the solution for eliminating porosity in all die castings. The reader must still form his own conclusions based on experience and knowledge of the particular die casting involved. The author is mainly concerned with the production of die castings with better qualities than those produced by conventional methods.

To begin with, theoretical aspects of fluid flow are applied to pressure die casting; this is done to explain and illustrate the process of filling a die cavity with molten metal under pressure. Readily acceptable as a cause for runner porosity is the author's concept of filling. First, an outer skin forms on the die face as the metal flows into the cavity (similar to the "rolling out of a carpet"), and, next, the core is filled. Turbulence encountered in filling a die cavity, with or without skin formation, is also acceptable as a cause of porosity.

The effect of pressure variation during the die filling phase is also considered. Increases in back pressure and temperature changes in the metal, though they may be small, result in changes in metal viscosity to cause variations in pressure. Further, the conversion of kinetic energy into thermal energy results in an appreciable pressure variation that may even cause a secondary "flash" formation in dies that are not thermally compensated or firmly locked in position. The ratio of gate depth to casting thickness is discussed with reference to both filling time, and the result and effect on porosity. Of interest also is a discussion concerning the back pressure shock when the cavity is completely filled.

Presenting as it does many leads for further work, this paper is a valuable contribution to the science of pressure die casting. Methods for improving present techniques are also indicated. The presentation is not conclusive, but does indicate many factors to which porosity can be attributed. Details in the paper lessen its interest for the casual reader, but the producer of die cast-

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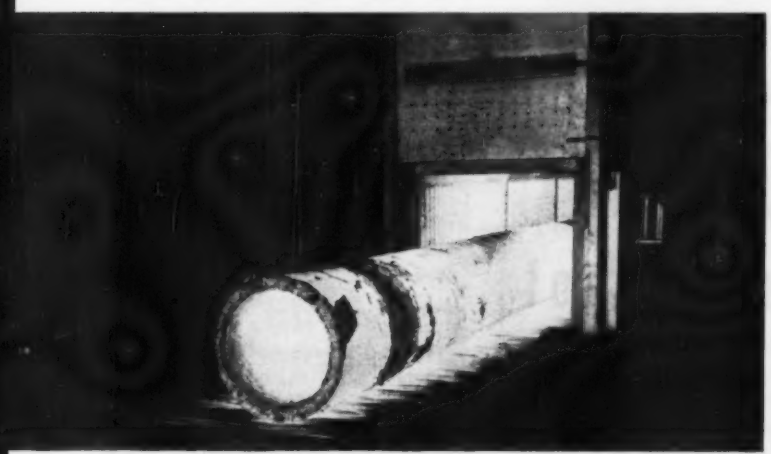

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Circle 523 on Page 48-S

Die Casting . . .

ings or the researcher will find it has real value.

Vacuum Die Casting

The second paper concerns the results of vacuum die casting. It discusses many variations in vacuum technique and procedures, and illustrates how they may be applied to die casting. Principal benefits include: degassing of the melt, preventing oxidation of the more reactive elements, decreasing the time required for cavity filling, and producing components entirely free of porosity. This porosity-free effect, however, turns out to be a "serendipity" (unexpected advantage or "lucky break") as the original objective was to speed up cavity filling.

Illustrations and text material outline vacuum die casting methods and techniques that will produce castings of superior quality in shorter cycles. Vacuum investment casting, gravity die casting under vacuum, and conventional vacuum die casting are methods presented in some detail.

The dangers encountered in vacuum die casting are also presented. These cover methods of excluding metal from vacuum lines, hydrostatically operated cutoff systems, accurate timing control, connection of vacuum lines, and use of the ejector box as a despression chamber. The use of cores presents a problem in vacuum die casting; moving cores might unduly affect the pressure reduction. Methods for nullifying this effect are presented.

Five methods for providing an evacuable chamber between die platens, the primary requisite for vacuum die casting, are listed. The list includes techniques used by the Russians. Each methods is discussed in some detail, and additional possibilities, such as operating a machine in an evacuated enclosure, are indicated.

As in the first article, the author has presented methods and techniques that are of considerable value to those engaged in the production of quality die castings. The various methods presented are illustrated and complete understanding may readily be obtained by the reader.

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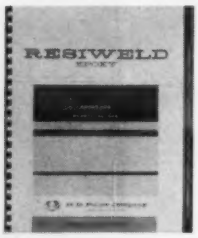

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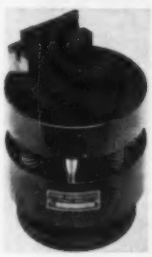

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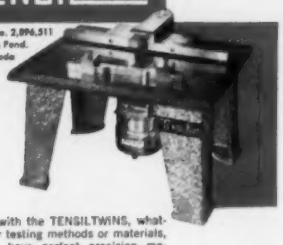

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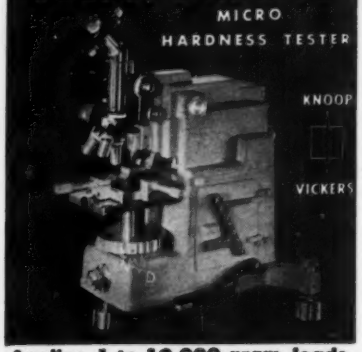

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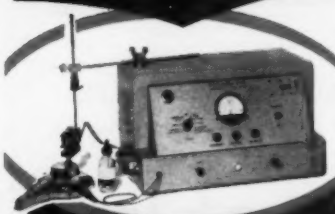

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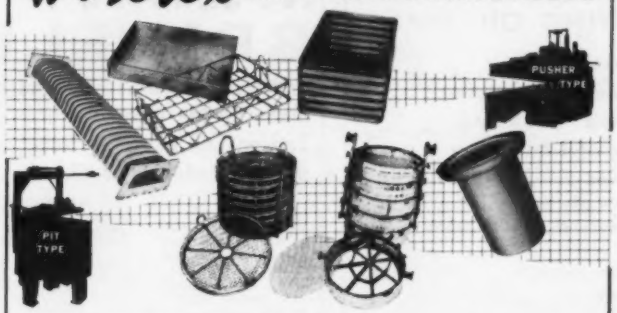

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New

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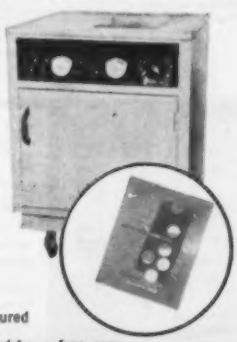

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Circle No. 28 on Page 48-B

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Published, 1960

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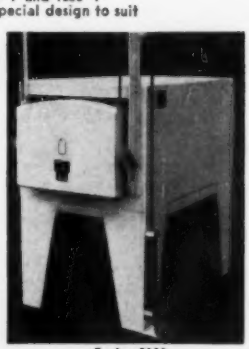

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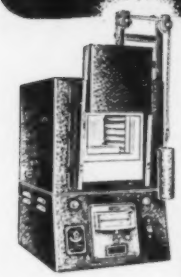

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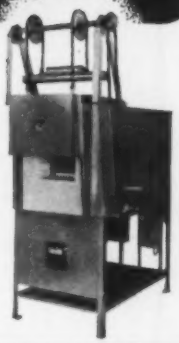

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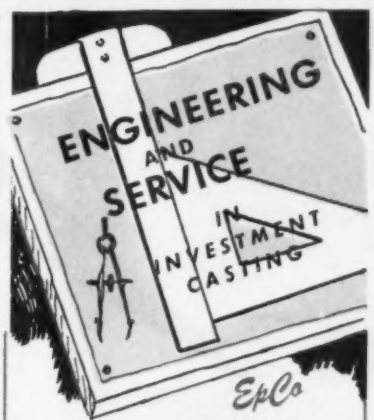

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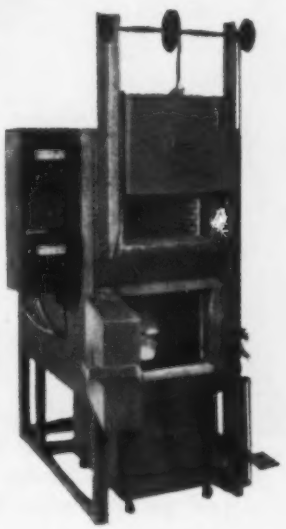

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Vibrations Form Metal

Digest of "Metal Forming by Vibration", by M. Ya. Karnov and A. A. Voronin, *Kuznechno-Shtampovochnoye Proizvodstvo*, No. 3, March 1960, p. 3-8.

WHILE UNCONTROLLED VIBRATION is detrimental to metalworking operations, recent Russian investigations have shown that vibrations of a definite frequency and amplitude can be applied to intensify plastic deformation. The results indicate that vibrational deformation is more uniform over-all (than static forming) because a greater number of microscopic areas are strained within the metal. Due to the intermittent nature of loading, surface friction is decreased.

Other advantages: Contact surface friction is decreased as much as 40%; plasticity is increased as much as 40% in light alloys, titanium and constructional steels; press effort is decreased up to 1.5 to 2 times, resulting in longer tool life and decreased tonnage requirements; dimensional precision is considerably improved.

Vibrational deformation was evaluated by comparing the performance of a 350-ton vertical hydraulic press equipped with a mechanical vibrating device (capable of imparting up to 1500 vibrations per min.) with that of a 1000-ton coining press. Small specimens of low-alloy steel (0.40 C, 0.25 Si, 0.65 Mn, 0.75 Cr, 1.45 Ni, 0.20 Mo) and aluminum alloys AK-6 (2.2 Cu, 0.6 Mg, 0.6 Mn, 0.9 Si) and VD-17 (2.7 Cu, 2.2 Mg, 0.55 Mn) were hot and cold upset with and without lubrication.

Experimental results are summarized in Fig. 1. They show that plasticity is improved and less press effort is required when the vibrational effect is applied. For example, a specimen first upset with a static force of up to 45 tons, then with a vibrational force of 80 tons, at 940 to 990 vibrations per min. (curve 2), achieved the same degree of deformation as the specimens initially upset with the static forces of 70 to 90 tons (curves 3 and 4).

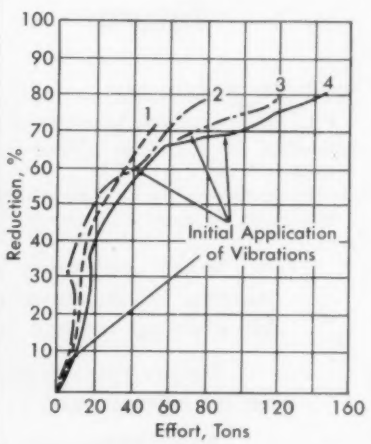

Fig. 1 — Relationship Between Deformation and Effort (Pressure) in Upsetting Specimens 25 Mm. Diameter and 10 Mm. High of Aluminum Alloy VD-17 in Static Deformation Followed by Application of Vibrational Force. For curve 1, static force was 12.5 tons when vibrational frequency (940 to 950 per min.) was applied. For curve 2, static force was 45 tons when vibrational frequency (940 to 990 per min.) was applied. For curve 3, static force was 70 tons when frequency (990 to 1000 per min.) was applied. For curve 4, static force was 90 tons when frequency (1010 to 1020 per min.) was applied

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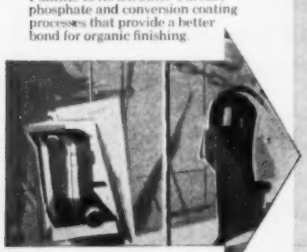

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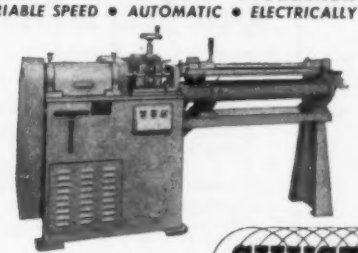

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Circle 537 on Page 48-B

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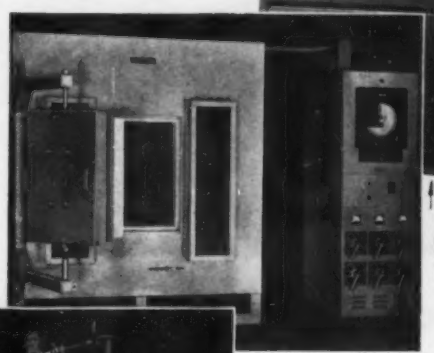

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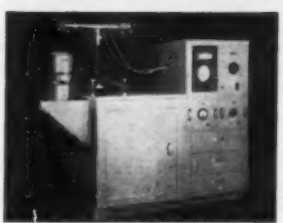

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HARROP PRECISION FURNACE CO.
Dept. M (formerly Harrop Electric Furnace Division)
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Circle 538 on Page 48-B

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UNITCAST CORPORATION, Steel Foundry Division, Toledo 9, Ohio
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Unitcast

SPECIFICATION STEEL CASTINGS

Circle 539 on Page 48-B

Vibrations . . .

Various other bits of information were also obtained. For instance, round shapes were most favorable for upsetting by vibration.

Specimens of AK-6 aluminum achieved greater reduction (70%) without cracking when deformed vibrationally. Cold plasticity of aluminum alloy VD-17 was improved 30 to 40%, and hot and cold plasticity of titanium alloy VT-2 improved 25% compared with working in a coining press.

The vibrationally deformed specimens were examined to reveal a metal structure favorable to plastic deformation. Flow lines were almost perpendicular to the surface, and the metal fibers were not "bent". Grain size was finer and more uniform, and the surface and interior hardness more uniform than that of the hydraulic press product. The mechanical properties were typical for these alloys. Dimensional accuracy was improved: side surfaces were 60% flatter and over-all dimensions 50% closer to the finished requirements.

Aluminum alloy blades of VD-17 are currently produced by this method in "line production" with tolerances of 0.05 mm. and improved surface quality over the forging or coining press products.

ARTHUR B. TESMEN

Rapid Recrystallization of Steel

Digest of "Peculiarities of Transformations During Rapid Recrystallization of Steel", by F. K. L'vov, *Nauchn. Doklady Vyssh. Shkoly-Metallurgiya*, January-March 1959, No. 1, p. 203-5; Brutcher Translation No. 4716.

RAPID HEAT TREATMENT of cold worked wire and strip steel is steadily attracting more and more attention because of the possibilities for increasing production, product quality and uniformity, as compared with conventional methods. However, studies show that a number of peculiarities occur when such materials are rapidly heated.

In this investigation, specimens of 0.08% C rimmed steel were cold reduced 60% to 1 mm. (0.04 in.).

These specimens were then heated by a high frequency (200 kc. per sec.) for times which ranged up to 6 sec. When heating was completed, the specimens were cooled by water spraying.

With an increased heating rate, recrystallization shifts to higher temperatures and occurs much faster. In a steel heated to 650° C. (1200° F.) at 1500° C. (2700° F.) per sec., three periods of change can be observed. In the first, which lasts 0.5 to 0.6 sec., relaxation causes small changes. In the second (from 0.6 to 1.2 to 2.4 sec.) decided changes in structure and steel properties occur along with grain coarsening.

When temperature is increased to 1560° F. (see Fig. 1), the first and second periods are shortened, independently of whether the heating temperature is below or within the critical range. Property changes

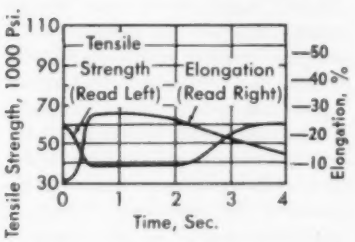
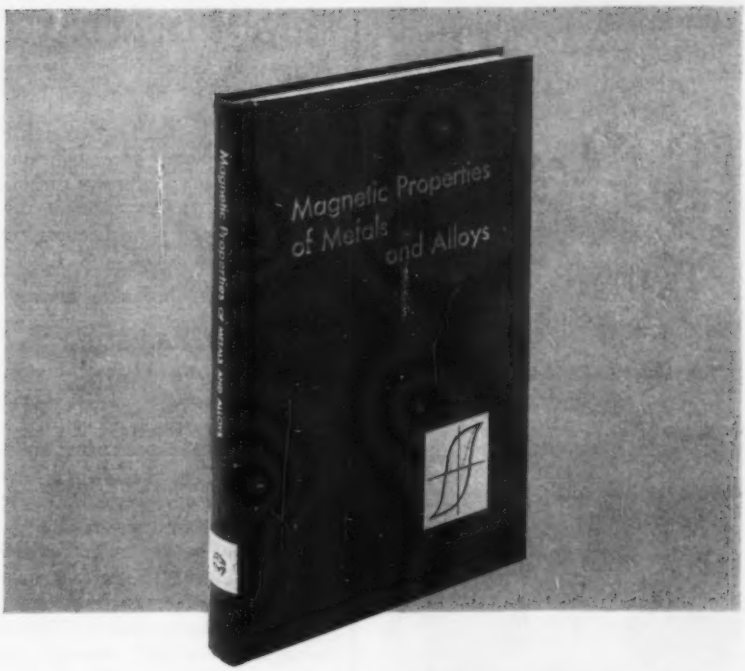


Fig. 1 — Variation of Properties With Heating Time. The metal is 0.08% C rimmed steel, and the heating rate is 2700° F. per sec. for holding at 1560° F.

associated with relaxation are completed within fractions of a second, while recrystallization requires only about 0.5 sec. Grain growth develops in 1.5 to 2 sec. after which a fourth period is revealed. This is characterized by increased strength and reduced ductility of the steel.

The structure of the third period consists of recrystallized ferrite grains and carbide. In specimens quenched after heating for times corresponding to the fourth period, a new structural constituent, an acicular type formed around carbide inclusions, appears. When the heating time within the fourth period is increased, more acicular constituent appears. The carbide phase also departs.

Apparently, with high heating rates carbides do not have time to dissolve during the short time in



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Recrystallization . . .

which the cold worked structure recrystallizes.

Specimens heated long enough to insure complete recrystallization (but not enough to dissolve carbide) did not age. However, samples recrystallized with slow heating and rapid cooling did age. C.R.W.

How Radiation Affects Metals

Digest of "Effect of Nuclear Radiation on Engineering Materials", by A. H. Cottrell, *Chartered Mechanical Engineer*, March 1960, p. 105-119.

THERE ARE THREE main types of radiation damage: electronic damage (electrons are knocked out of their orbits into states of higher energy); "knock-on" damage (an entire atom is knocked out of its place in the material by a heavy collision from a nuclear particle — and often knocked out so violently that it, in turn, knocks a cascade of other atoms out of place); and transmutation damage (a neutron enters an atomic nucleus and causes it to transform into a different chemical element, often emitting enough energy in the process to produce severe electronic and "knock-on" damage).

Luckily, only two of these three apply when metals are irradiated. Metal is immune to electronic damage, because the electrons in the metal structure are able to flow freely from place to place in a metal and if an electron is knocked out of one place, it can be immediately replaced.

"Knock-on" damage in metals is caused by neutrons which strike an atom hard enough to dislodge it from its site in the material. This releases energy sufficient to knock out many more atoms, forming what is known as a "spike" of radiation damage. In a crystalline solid, each atom knocked out leaves behind a small hole of one atomic volume which is called a vacancy; the atom itself usually comes to rest in some place between the crystal layers, where it is called an interstitial. A spike thus consists of a rather elongated cluster of point defects with vacancies mainly in the center and interstitials around the edge.

Calculations have shown that during a long period in a reactor (say 20 years) a material has every one of its atoms knocked out of place at least once. That some materials can retain their original properties after this treatment is because the damage can be annealed out. If the temperature is not too low, a point defect and a vacancy can migrate together and annihilate each other. If defects of the same type meet, they can often join together into more stable arrangements.

Transmutation damage may be found in substances such as boron, beryllium, lithium and uranium. In uranium, a slow neutron causes the nucleus to break up into two smaller nuclei (for example, of substances such as strontium, krypton, iodine and xenon). The damage caused by these fission fragments is very large, amounting to 10^4 to 10^5 displaced atoms.

One of the most familiar effects in physical metallurgy is that foreign atoms dispersed in solution in a metallic crystal or distributed in the form of finely dispersed precipitates harden the metal. Since the point defects which may be produced by radiation damage are similar in some ways to foreign atoms, metals can be hardened by irradiation. Neutron irradiation hardens metals rapidly at first, but the reaction slows down. The yield strength of mild steel can be increased by 20,000 psi. for an irradiation dose (neutron flux) of 10^{13} for four months. The ductility of the metal decreases; this could be important for structural components of a pile which have to accommodate themselves plastically to distortions which occur in the fuel rods.

What is the cause of radiation hardening? This can be explained if it is considered that the yield strengths of metals are determined by the stresses which are needed to start, and to keep, dislocations moving across a slip plane. The point defects produced by irradiation can pin dislocations preventing any movement. Clusters of point defects, or spikes, can provide a "frictional" resistance to the movement of dislocations through the lattice. Recent work, however, has shown that the latter effect is more prominent.

The effect of irradiation on mild steel is not limited to an increase in the yield strength. The ductile-to-

brittle transition temperature is also increased, a fact very important in considering the use of mild steel for the reactor pressure vessel. Current practice in the United Kingdom is to recommend that utmost care be taken with the fabrication and welding of reactor pressure vessels, and that all welds be radiographically inspected and the complete structure stress-relieved.

One of the most serious practical effects of radiation occurs in the uranium fuel itself and takes the form of dimensional instability. The changes are as follows:

1. Thermal cycling growth, occuring when a bar of uranium is heated and cooled many times between room temperature and 600° C. (1110° F.). It appears to be due to a large anisotropy of thermal expansion in the alpha uranium crystal.

2. Radiation growth, causing uranium bars to grow at temperatures below about 400° C. (750° F.)

3. Swelling, essentially a change of volume of the uranium bars, due to the formation of pockets of gaseous fission products (mainly krypton and xenon) inside the metal which puff it up at temperatures above 500° C. (930° F.) into a porous mass. W. A. MORGAN

Bonding Steel With Plastics

Digest of "Kleben von Stahl mit Kunstharzklebern", by Karl Möhler, *VDI Zeitschrift*, Jan. 1, 1959, Vol. 101, p. 1-8.

THOUGH MOST REPORTS concerning the bonding of metals with plastic adhesives are about aluminum or light metal alloys, there appears to be no reason why sheet steel cannot be bonded in the same way. In fact, German engineers are now using plastics to glue steel bridges. The builders have been joining the bridges with high-stress screws. At first the surfaces to be joined were roughened (by sand-blast or flame) to increase friction between them. The next step was to substitute a thin layer of adhesive to achieve bonding effect previously obtained by friction.

According to the article, an adhesive suitable for structural steel work must meet certain standards. It should be applied at ambient temperatures, and set in a short time without application of pressure or heat. Also, the final strength of joint must be equal to or higher than the shear strength of the steel, and the joint must withstand temperatures from −35 to +80° C. (−38 to +180° F.) and other climatic influences. Finally, the thickness of the adhesive layer must not affect adversely the strength and life of the joint.

Adhesives with these properties are high-molecular, organic, hardenable substances whose molecules adhere to metal. Present experience indicates that phenolic resins, epoxy resins and unsaturated polyester resins are best suited for adhesive compounds. With all adhesives it is important that contact surfaces are free of oil, grease, dirt, and other contaminants. Optimum adhesion can be obtained by roughing the surfaces (thus increasing the contact area).

The research laboratories of the Karlsruhe Technical Institute were asked to find the most suitable adhesive for constructing a tubular steel pedestrian bridge spanning a ship canal. After their engineers decided to use "Vestopal" (a trade name) for the bridge construction, they made a comprehensive series of tests to establish what strengths were needed for the adhesive compounds. They also determined the best conditions for applying the adhesive, and studied the reaction of the compounds under continuous load conditions and in different temperatures.

As a safety measure, screws were added to hold the glued surfaces together during erection of the bridge. (Besides, the screws would keep the bridge from collapsing if the adhesive should fail after prolonged exposure to the elements. Up to that time, no data on the durability of the adhesive were available.)

Comparison between the structural strength of conventional and glued joints showed that the contact area of glued joints would have to be increased considerably to match the strength of a riveted or welded joint. However, the experiences gained in constructing the glued bridge form the basis for further research. Durability of the bridge will, of course, determine whether plastic adhesives will find extensive use in structural steel work.

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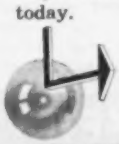

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Bonding Steel . . .

tion of economy was obviously of secondary importance. It seems that the greatest potential field of application would be in light construction work where reinforcements are often needed to offset a tendency of such structures to buckle and bulge. Bonding by adhesives can provide this reinforcement if the necessary contact area is available. Bonding may also be advantageous where welding cannot be used because of the adverse effect of heat.

K. C. SPENCER

Hafnium Carbides

Digest of "Hafnium Carbide-Containing Hard Metals", by R. Kieffer, F. Benesovsky and K. Messmer, *Metallwissenschaft und Technik*, Vol. 13, No. 10, 1959, p. 919-922; Brutcher Translation No. 4722.

ALTHOUGH STUDIES OF hafnium carbide date back to the thirties, it is only recently that enough hafnium has become available to make its carbide worth investigating as a possible constituent of cemented carbides. Hafnium carbide (HfC) can be produced by carburizing the oxide with carbon black in a hydrogen atmosphere at 2200° C. (4000° F.). Its diamond pyramid hardness (load, 50 g.) is 2600; thus it is softer than TiC (3200) but harder than TaC (1800) and WC (2400). It melts at about 4200° C. (7000° F.).

The carbide, which is face-centered cubic, forms solid solutions with TiC, ZrC, CbC and TaC, but there is very little solubility with VC. At 2000° C. (3600° F.), it can dissolve up to 40 mole% (21 wt.%) WC, but this is considerably less than can be dissolved by TiC. In a cemented carbide containing HfC as well as a large amount of WC, both the solid solution of the two carbides and free WC are present in the microstructure. After being sintered with cobalt, particles of HfC are rounded because it dissolves to some extent in this metal.

A number of hard carbides were hot pressed into compacts containing 10% Co for a binder. The HfC compact was a little softer than the TiC and ZrC compacts, about the same in hardness as the WC com-

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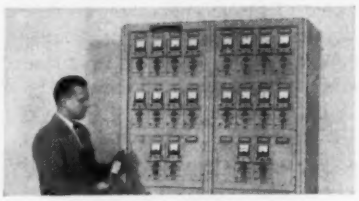

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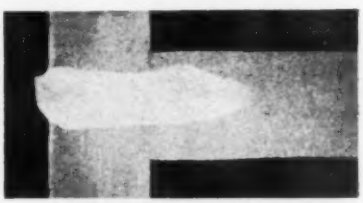

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pact, and harder than the rest. In bend strength, the HfC material was considerably better than most of the other cemented carbides, but it was 45% weaker than the WC material.

Since it was expected that HfC would be resistant to cratering because of its similarity to TiC, the cemented carbide blanks were limited to the steel-cutting and "universal" grades, the latter being suitable both for steel and cast iron. TiC was replaced either by an equal weight of HfC, or else by 2.5 times as much to compensate for the large difference in density. TaC was replaced by an equal amount of HfC since their densities are fairly close. Because the mixes had to be relatively small (200 g.), premilled solid-solution carbides were used in them. The compacts were sintered in vacuum at 1460° C. (2600° F.).

There was no consistent pattern with respect to hardness changes caused by the substitution of HfC for the other two carbides, but the bend strength was reduced by this substitution. Considerable microporosity was observed in the compacts containing HfC, and also a few large pores were found. Apparently this was because the HfC was only of commercial purity, though there was also some difficulty in processing the limited amount of material available.

The cutting performance was evaluated by turning tests on steel (130,000 psi. tensile strength). It was found that replacement of TiC in WC-TiC-Co compositions by an equal volume of HfC did not appreciably affect the flank wear, but did reduce the resistance to cratering. When the TaC in a WC-TiC-TaC-Co composition was replaced by an equal weight of HfC, the cutting performance remained the same in one test and improved slightly in another. A similar change in another WC-TiC-TaC-Co composition, designed for use in both steel and cast iron, did not affect the performance adversely for either of these work materials. If the unfavorable conditions of preparation and the above-average porosity are taken into account, cemented carbides containing

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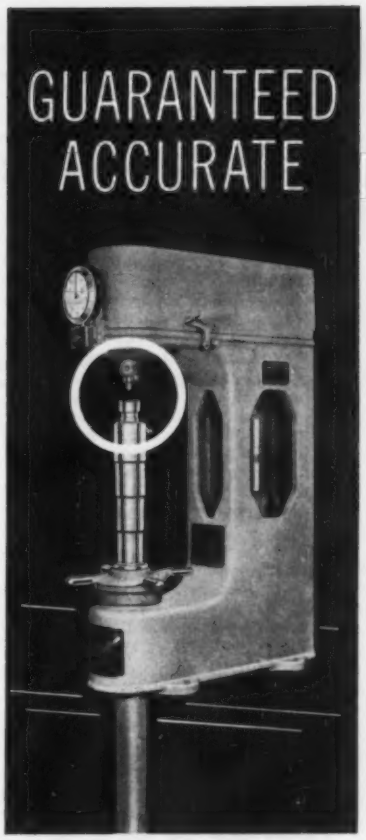

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Hafnium Carbides . . .

HfC had favorable physical properties and excellent machining characteristics, except for some instances of more pronounced cratering.

L. P. TARASOV

Hot Cracking of Weld Metal

Digest of "Determination of Susceptibility of Weld Metal to Hot Cracking", by M. Kh. Shorshorov and V. S. Sedykh, *Svarochnoe Proizvodstvo*, August 1958, No. 8, p. 10-14; Brutcher Translation No. 4821.

THIS PAPER concerns a method of testing that is supposed to evaluate the hot cracking tendencies of weld metal. However, the test seems inadequate since no consideration is given to the chemical composition of the base metal or that of the electrode except to note the classification (Russian) of the electrodes used in the tests.

For this test, an elaborate machine was built and used to variably load the test specimens as a weld bead was applied. Some attempt is made to evaluate the kinetics of the resulting weld procedure but the authors' development ignores every variable but one, the rate of loading.

The reviewer feels that one could more easily, and to a better degree, determine the hot cracking tendencies by making a test weld and then examining it metallographically.

W. T. TIFFIN

The L-D Process Today

Digest of "The Development and Present State of the L-D Process", by O. Cuscoleca and K. Rösner, *Journal of the Iron and Steel Institute*, Vol. 192, June 1959, p. 147-153.

THE LINZ-DONAWITZ (L-D) process of producing steel by blowing a converter with oxygen admitted through a lance insert at the top of the vessel is nearly 11 years old. Although the first commercial production only started in late 1952, the process is now used by 14 plants in various parts of the world. The annual production capacities of these plants range from 20,000 to 1.3 million tons and total more than 8 million tons. The 13 additional L-D plants under construction will soon raise the annual capacity to more than 14 million tons.

The early shops were equipped with vessels rated at 25 to 30-ton capacity; some newer plants operate with vessels holding 80 tons. Based on tap-to-tap times, the L-D converters produce steel at rates of 55 to 80 tons per hr. Oxygen consumption ranges around 1940 cu.ft., or 173 lb. per ton of steel. The capital cost for building an L-D shop is approximately 70% of that for an openhearth plant of equal capacity. Furthermore, the steelmaking process can be modified to use a variety of hot metal compositions to suit local conditions.

Since commercially pure oxygen is used, the L-D process produces steel with low hydrogen and very low nitrogen contents (0.002% N). The presence of a reactive basic slag and violent agitation helps to remove sulphur and phosphorus. By treating the iron with soda, sulphur contents below 0.015% can be attained. Depending on the iron analysis, particularly the silicon content, and the steel composition desired, scrap amounting to 10 to 35% of the charge weight is added to cool the vessel. Most L-D shops produce low-carbon steel, but the Donawitz plant produces higher-carbon and rail steels by the process. Such products require considerable skill and experience because of the rapidity of the oxidation reactions.

In Japan, two-slag processes are used with the oxygen converters to produce low-carbon steels with less than 0.02% P from irons containing up to 0.50% P. Double slagging combined with additions of fine ore to the first slag permits production of L-D steel from Austrian pig irons containing 0.50 to 1.50% P. The Mannesmann and Pompey plants have produced steel from irons containing 1.7 to 2.0% P. The first slag from this operation is a salable type of fertilizer containing about 20% P_2O_5 and 6% FeO. The second slag, containing less than 6% P_2O_5, is retained in the vessel and reused as the first slag for the following heat.

The L-D process has been modified in some plants by injecting pulverized lime into the vessel with the oxygen stream. This procedure has been used with basic-bessemer type hot metal in the ARBED plant

at Dudelange. Lime added amounts to about 230 lb. per ton of hot metal; other fluxes are not required.

Various operating economies have been obtained as experience has been accumulated with the L-D process. Loss of iron oxide as fume, which originally amounted to about 0.6% of the charge weight, can be eliminated by using suitable gas-cleaning systems. The life of the oxygen lance now averages 1000 heats or more and the life of the vessel lining has been improved. At Donawitz, linings of commercial, burned magnesite brick last for 500 to 600 heats. The vessels at Linz, lined with tardolomite brick containing a large percentage of magnesite, average 340 heats. Since some of the lining brick can be reused, the consumption averages about 8 lb. of refractory per ton of steel produced. At Donawitz, which uses a vessel with a detachable bottom, the crucible can be relined and made ready for operation in 75 hr. F. W. BOULGER

Blisters in Vitreous Enamels

Digest of "Influences of Hydrogen in Vitreous Enameling of Steels", by Gordon P. K. Chu, and "Blistering of Wet Process Vitreous Enamels on Cast Iron —Some Facts and Theories", by E. R. Evans and A. D. Morgan, *Bulletin*, Institute of Vitreous Enamellers, Silver Jubilee Conference Edition, p. 1-18 and 19-30.

FROM VERY EARLIEST TIMES, a technique has been used to cover metal surfaces with a fused glassy coating and produce artistic colors and patterns which remain unchanged, sometimes for centuries. A modern example is the beautiful white or colored surface of the cooking stove and other domestic appliances. The crude casting of iron or steel sheet is covered with a wet mixture of oxides, clays and fluxes, the composition being chosen over many years of experience. The metal and its covering are dried and fired, sometimes through several processes, and during this time the covering of enamel "frit" fuses and flows evenly over the surface. This process of vitreous enameling is still largely an art, but the papers presented to the Institute are exploring the science. Industrial terms abound in the papers and make reading difficult. "Blistering" consists of gas bubbles, pin holes and black specks, which originate probably at high temperature and are retained in the finished ware. "Fish scaling" is a chipping of the enamel in short or long periods after manufacture.

The first paper is concerned with "fish scaling" and it is assumed that hydrogen only is the cause of this defect. The paper collects and extracts a valuable bibliography of 40 publications between 1928 and 1959. The source of hydrogen is explored in all materials and processes, that is the metal, and enamel and furnace gases.

The average chemical composition is quoted for five typical steels with carbon content of 0.15% or less, but in no instance is a hydrogen content mentioned. It is said that a titanium bearing steel (0.3% Ti) and a 2 to 3% silicon steel are not susceptible to fish scaling, but in no instance is the defect associated with maximum or minimum content of hydrogen. It is probable that the steels mentioned are deoxidized in comparison with rimmed steel. A reference is quoted to show that titanium-bearing steel has a greater solubility for hydrogen than other steels, and it is suggested that the freedom from defects is due to retaining the hydrogen by occlusion during processing.

Hydrogen is said to arise from chemically combined water, which in some materials like borax is liberated only at high temperatures, 2370° F., and from hydroxyl groups in glasses which react with iron to form hydrogen. These hydroxyl groups may be largely removed by first melting the glass in a vacuum or flushing with dry inert gases.

The effect in furnaces is very definite. If the furnace gases contain more than 1.46 vol.% moisture, fish scaling will take place, but if less than 0.11%, there will be no defects.

The remainder of the paper is devoted to the evaluation of the diffusion and storage of hydrogen in steel. An electrolytic cell is devised with a platinum anode, 1% sulphuric acid in water for electrolyte, and cathode of sheet steel under test. Hydrogen is generated at the steel, and the point of permeation is when a bubble first nucleates on the opposite side. A steel may occlude large quantities of hydrogen or pass it through very quickly. It is claimed

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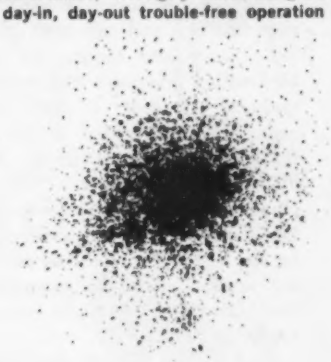

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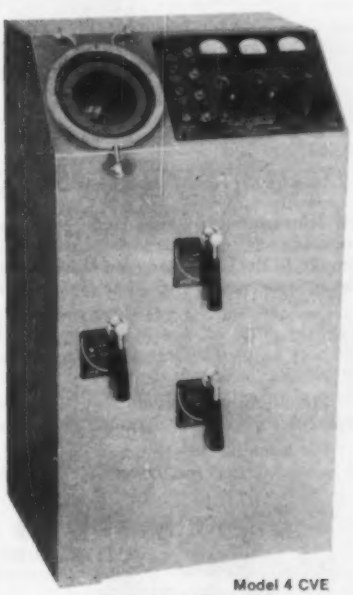

Model 4 CVE

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Blisters . . .

that steels which have a high occlusive capacity are always fish-scale resistant and vice versa. It can be inferred that this hydrogen diffusion cell may be used as a sorting test for unsatisfactory steels. A slow rate of cooling after firing will reduce fish scaling in the enamel, but this control must be economic. Some real progress has been made towards reducing the scrap below 55%.

The second paper is concerned with cast iron and only with blistering. Evans and Morgan are troubled with a practice which produces scrap of the order of 55%. Some eight firms cooperated to use controlled samples to explore the effect of processes on quality. They concluded that continuous furnaces rather than box type produce by far the best results and that products are satisfactory if the castings are shot-blasted very well and processed immediately.

Gas analysis reveals that blisters always contain oxides of carbon and little or no hydrogen. Microstructures of sections of metal and enamel show that blisters are always associated with outcrops of graphite or inclusions of iron oxide at the surface. There is no intrinsic gas content in the iron and since atmospheric oxygen is excluded by the covering of "frit", the gases must come from reactions between graphite and iron oxide. The paper does however admit that all enamels have a bubble structure adjacent to the metal, but it must not affect quality.

J. W. JONES

Boron in Bearing Steel

Digest of "Effect of Treatment of 1% C, 1.5% Cr Cast Bearing Steel With Boron Upon Some Properties", by A. I. Fal'kov, *Izvestiya VUZ-Chernia Metallurgiya*, No. 1, January 1959, p. 113-120; Brutcher Translation No. 4627.

TO STUDY THE INFLUENCE of boron additions upon the minimum austenitizing temperature required to achieve Rockwell C-61.0 (after a 1.5 hr. temper at 300° F.), researchers used samples of cast 0.001% and 0.002% B modifications of Sk Kh 15 steel (1% C, 1.5% Cr) along with forged samples of Sk Kh steel. With this material, they obtained the specified hardness at 760° C. (1400° F.) and 780° F. (1435° F.) with the boron modified steels, whereas 800° C. (1470° F.) was required with the standard steel.

Next metallographic examination and chemical analysis were performed. The testers found that the standard steel quenched from 780° C. (1435° F.) contained some high-temperature transformation product; they did not see any in the boron treated steels quenched from the same temperature. Also the boron treated steel quenched from 840° C. (1545° F.) had 1.07% Cr in solution against 0.9% Cr in solution for the standard cast steel quenched from the same temperature.

Strength and ductility of the standard and boron treated steels were compared by using a special compression test. Samples 5 mm. (0.2 in.) diameter, 8 mm. (0.315 in.) high were hardened from 840° C. (1545° F.) in oil, tempered 1.5 hr. at 150° C. (300° F.) and pressed into hollow cylinders of Steel 20 (S.A.E. 1020) of 18 mm. (0.71 in.) O.D. The composite specimen was tested in compression and the results compared with similar tests of solid Steel 20 samples to obtain the "reduced" stress. The results showed that the cast boron treated steels had strength and ductility equivalent to homogenized and forged samples of identically hardened standard steel. The best properties were obtained with the boron treated steel hardened after homogenizing and isothermally annealing to "divorced pearlite".

W. E. LITTMANN

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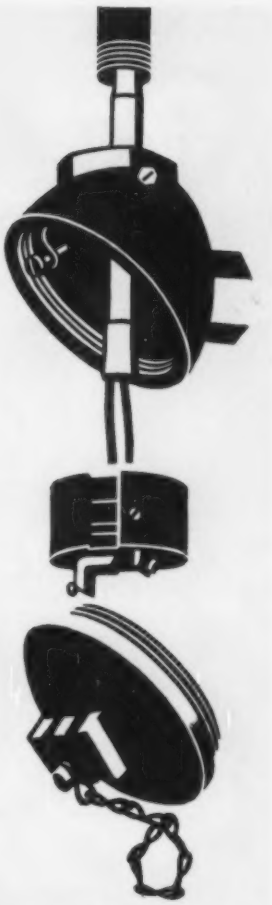
BEHIND THE BYLINES

Hans Meyer, author of the report from Germany on new carburizing steels in use there by automakers (p. 70), was born in Bern, Switzerland, and graduated from the Mining and Metallurgical University at Leoben, Austria, receiving a metallurgical engineering degree in 1931 and a doctorate in 1933. After working in foundries and steel works in France, the United States and Switzerland, Dr. Meyer opened the first development and sales office on the European continent for Climax Molybdenum Co. and is director of the Zurich office. His article is a result of the new innovations brought about by the rapid postwar development in Europe, and he would like to thank his friends in the German steel and automotive industries for the help given him in compiling it.

How D. Napier & Son Ltd., London, designed and built a creep tester in only five weeks is related by H. Robson, metallurgist in charge of the company's creep testing laboratory (p. 76). Educated at Sunderland Technical College, Mr. Robson worked a short time as laboratory assistant in the petrol plant of Imperial Chemical Industries, then with Shell-Mex and British Petroleum as plant chemist and trainee supervisor in the grease plant. After the outbreak of war in 1939, he joined the Ford Motor Co. Ltd. plant producing aircraft engines where he worked as metallurgical chemist, later becoming interested in the development of electropolishing techniques for metallographic specimens. When production of the Rolls-Royce Merlin engine terminated at the end of the war, he joined the staff of D. Napier & Son's metallurgical research laboratory where his continued interest in electrolytic polishing resulted in the adoption of this technique



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Behind the Bylines . . .

as a production process for inspecting aluminum bronze compressor blades. In December 1949 he installed the company's creep testing facilities and was named metallurgist-in-charge.

Heinz W. Balster, author of "Large Steel Castings for Heavy Duty", has spent more than 30 years in the German steel industry. Graduating as a specialist in ferrous metals from the Technishe Hochschule Aachen in 1927 (and with a doctorate in engineering in 1941), he went into industry, organizing the production control of the fully integrated steel plant of Stahlwerk Hoesch Dortmund. In 1934 he became chief metallurgical engineer for the Ford Motor Co. in Cologne, West Germany, where he was responsible for the testing and use of all materials used in building automobiles and trucks for seven years. He joined Ruhrstahl A.G.'s Witten-Ruhr works as chief of development and research for the companies six different works, then in 1945 became managing works director of one of Ruhrstahl's divisions, Annener Gusstahlwerk in Witten-Annen. This plant had been completely dismantled and it was his job to reconstruct it for the manufacture of railroad cars, large centrifugal pumps, machine tools and tractors. Five years ago he was again transferred back to the main company as director of development and research in Düsseldorf.

The status of welding processes in Europe is discussed by Maximilian Komers, chief engineer at Phoenix-Rheinrohr, A. G., Düsseldorf, and chairman of the International Institute of Welding's Committee on Special Arc Welding Processes. He was first employed in the research department of a big steel manufacturing group, and for the past 12 years has been responsible for the introduction of new welding processes and the development of welding equipment at Phoenix-Rheinrohr.

In addition to his activities with the International Institute of Welding, he is a member of Verein Deutscher Eisenhüttenleute and Deutscher Verband für Schweisstechnik.

The major part of A. C. Benning's 21 years with Harshaw Chemical Co., Cleveland, has been spent in electroplating work. His article on decorative plating abroad (p. 113) is based on first-hand experience in the foreign field, including 2½ years in England, where he established a Harshaw subsidiary in 1956 and had many contacts with metal finishing work on the Continent. Earlier this year he spent nine weeks in Europe attending technical conferences in Sweden and England and surveying developments in the European plating industry.

He received his B.S. degree in chemical engineering from Case Institute of Technology.

Charles A. Godden, who describes a vacuum desposition technique for the study of thin oxide films and a versatile mounting material, diallyl phthlate, on p. 121, was born in Hamilton, Ont., but received his schooling in London, England. He worked for R. and J. Beck Ltd. for 18 years before joining the Defence Research Board in Halifax in 1951 where he presently is senior metallurgical technician at the Naval Research Establishment.

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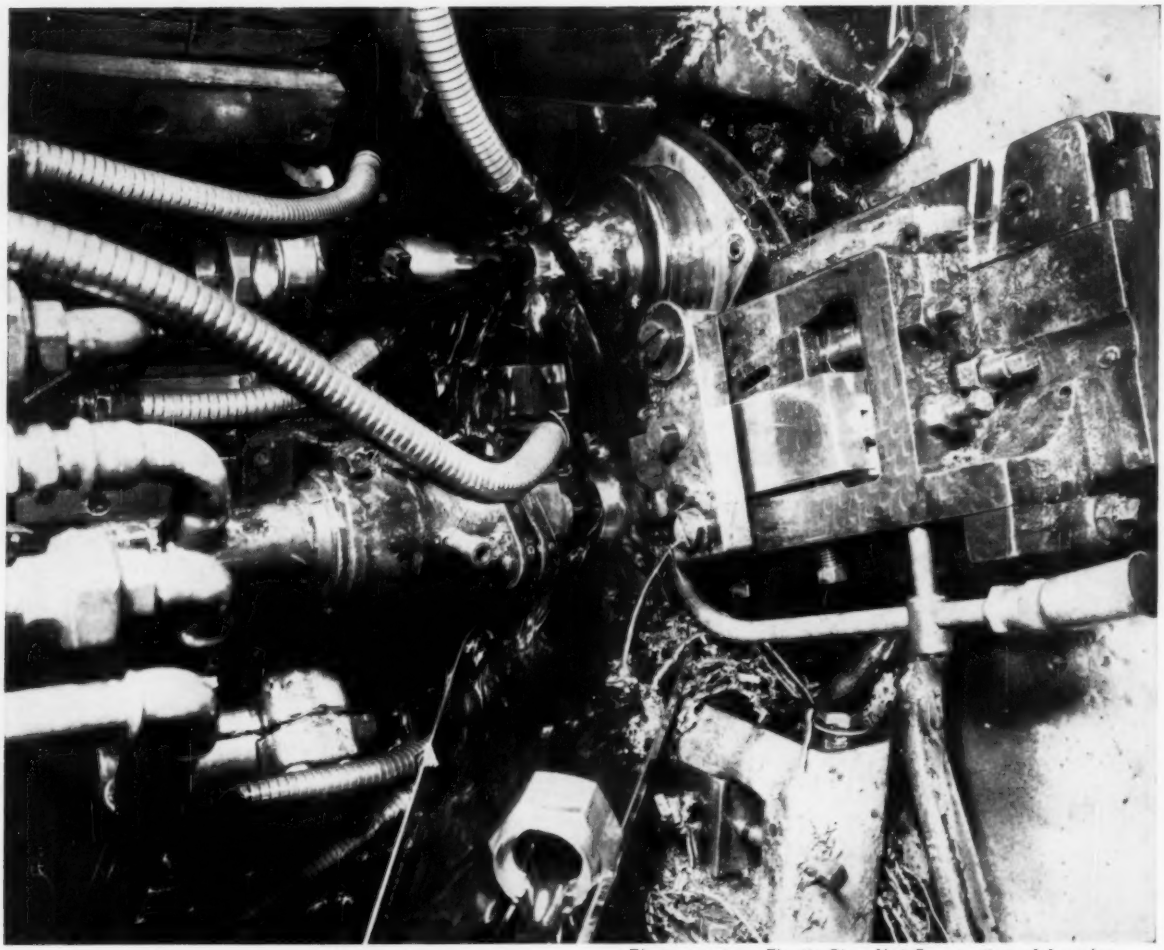

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